Department of Defense
Legacy Resource Management Program

PROJECT NUMBER 10-460

Climate Change Vulnerability Assessment Guidance for Conserving DoD Ecological Resources
Workshop Training Materials

January 2011

Tuesday, August 16 (incl. one hour for Lunch):

8:00 Opening Plenary and Introduction – Room 161 – *Donna Brewer/Naomi Edelson*

Click on link to view Video of Introduction.

Unit 1 - Overview of Vulnerability Assessment (1) – *Patty Glick (lead) Video of Presentation and PDF of Presentation.*

Introductions – participants – *Donna Brewer*

Foundational Concepts and overview of key steps (2) – *Patty Glick Video of Presentation and PDF of Presentation*

- **Using Vulnerability Assessment Results to Inform Agency Decisions** (3) **–** *John O'Leary Video of Presentation and PDF of Presentation.*

Unit 2 - Elements of a Vulnerability Assessment – *Kyle Barrett (lead)*

- **Assessing Sensitivity** (4) – *Kyle Barrett Video of Presentation and PDF of Presentation.*
  - **Break-out: Assessing Sensitivity**
- **Assessing Exposure** (5) **–** *Patty Glick Video of Presentation and PDF of Presentation*
  - **Break-out: Assessing Exposure**
- **Adaptive Capacity** (6) – *Bruce Young Video of Presentation and PDF of Presentation*
  - **Break-out: Assessing Overall Vulnerability**
  - **Breakout sessions - *Report to assigned Break Out Rooms- Return to Room 161***

5:00 Adjourn

Wednesday, August 17 (incl. one hour for Lunch):

8:00 Review and Insights from Day 1 – Room 161 – *Naomi Edelson*

Unit 3 - Part 1 - Approaches to Vulnerability Assessment – *Hector Galbraith (lead)*

- **Species Distribution Models** (7) **–** *Kyle Barrett Video of Presentation and Pdf of Presentation*
- **Vulnerability Indices – Habitat** (8) **–** *Hector Galbraith Video of Presentation and Pdf of Presentation*
- **Vulnerability Indices – Species** (9) **-** *Bruce Young Video of Presentation and Pdf of Presentation*

- **Expert Elicitation** (10) **-** *Hector Galbraith*

Unit 3 – Part 2 – Uncertainty – *Hector Galbraith (lead)*

- **Tools for Assessing Uncertainty** (11) **-** *Hector Galbraith*
    - **Break-out: Tools Café' –** *Jennie Hoffman - **Break Out Rooms located in six locations***

Unit 4 – Building a Vulnerability Assessment – *Jennie Hoffman (lead)*

- **Scale** (12) **–***Hector Galbraith* Video of Presentation and PDF of Presentation
- **Determining Objectives and Scope** (13) **–** *Bruce Young*
- **Selecting Tools and Data** (14) **–** *Jennie Hoffman*
    - **Break-out: Build your own Vulnerability Assessment**

Breakout sessions - ***Report to assigned Break Out Rooms***

5:00 Adjourn

Thursday, August 18 (incl. one hour for Lunch):

8:00 Review and Insights from Day 2, Check on Exercise – Room 151 – *Jennie Hoffman*

- Break-out (continued): Build your own Vulnerability Assessment

- **Team Reports: Build your own Vulnerability Assessment**

Unit 5 – Interpreting and Applying Assessment Results (15)**–** *Hector Galbraith (lead)*

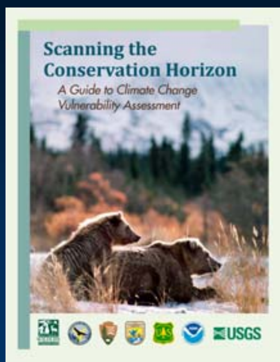
- **Vulnerability Assessments as an Essential Component of Adaptation Planning and Implementation** (15) **–***Hector Galbraith*
    - **Break-out: Acquisition and Management of Sites that are Vulnerable to Climate Change – Century Bog, A Case Study** (16)

Unit 6 – Wrap-up and Evaluation – *Naomi Edelson*

- **Benefits of Conducting a Vulnerability Assessment –** *Naomi Edelson*
- **Highlights –** *Participants*

- **Next Steps –** *All Instructors*
- **Feedback and Evaluation –** *Donna Brewer*

5:00 Thank-you and Conclusions – *Donna Brewer*



Climate Change Vulnerability Assessment Training Course

August 16-18, 2011

Unit 1: Presentation 1
Overview of Vulnerability Assessment

Patty Glick
National Wildlife Federation

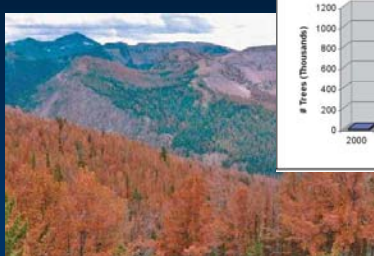
Session Goals

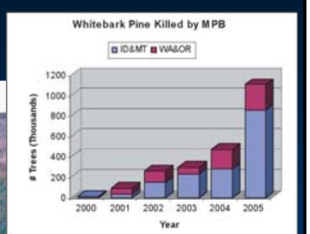
- Introduce climate change adaptation and the role of vulnerability assessment
- Summarize how vulnerability assessments can be used
- Review overall course outline and structure
- Enable participants to share interests and experiences with vulnerability assessment

"I skate to where the puck is going to be, not where it has been."
- Wayne Gretsky

"The Future is Not What it Used to Be"

We are Already Facing Change





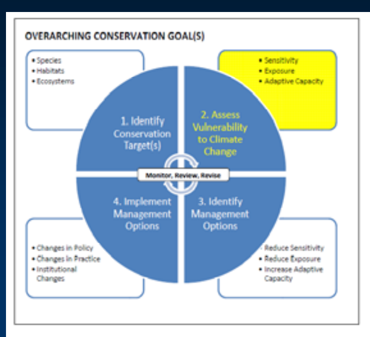
Responses to Climate Change

- Mitigation
  - Addresses causes of global warming
  - Focus on reducing greenhouse gas emissions
- Adaptation
  - Addresses impacts of global warming on people and ecosystems
  - Focus on coping strategies or safeguards

Adaptation Defined

Initiatives and measures designed to *reduce the vulnerability* of natural and human systems against actual or expected climate changes

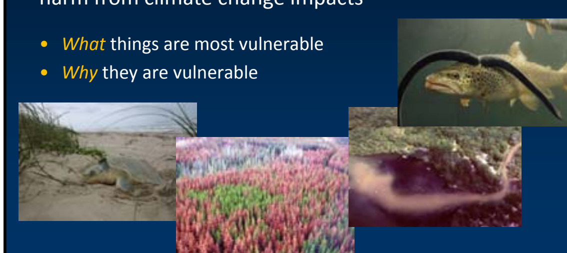
Adaptation Planning Framework



Defining Vulnerability

Climate change vulnerability refers to the extent to which a species, habitat, or ecosystem is susceptible to harm from climate change impacts

- *What* things are most vulnerable
- *Why* they are vulnerable



Why Assess Vulnerability?

Vulnerability assessments can help:

- Prioritize species and systems for management actions
- Develop management strategies to address climate change
- Efficiently allocate resources

What vulnerability assessments *don't* do:

- Make a conservation decision for you

Key Course Objectives

- Understand vulnerability assessment in broader context of adaptation planning
- Evaluate factors influencing vulnerability and how they affect an assessment
- Understand strengths and limitations of various approaches
- Design a vulnerability assessment applicable to your needs
- Interpret assessment results and communicate results to stakeholders

Course Outline

1. Overview and Foundational Concepts (Tues)
2. Elements of a Vulnerability Assessment (Tues)
3. Approaches to Vulnerability Assessment (Wed)
4. Building a Vulnerability Assessment (Wed - Thurs)
5. Interpreting and Applying Results (Thurs)
6. Wrap-Up and Evaluation (Thurs)

Unit 1: Presentation 2

Foundational Concepts and Overview of Key Steps

Patty Glick
National Wildlife Federation

Session Goals

- Unpack the concept of vulnerability
- Emphasize the importance of defining goals based on user needs
- Review assessment design considerations
- Summarize key assessment steps

Key Steps for Undertaking a Vulnerability Assessment

1. Determine objectives and scope
2. Gather relevant data and expertise
3. Assess the components of vulnerability
4. Apply assessment results in adaptation planning

Steps 1 and 2

1. Determine objectives and scope
   - Audience/user needs
   - Goals and objectives
   - Assessment targets (species, habitats, ecosystems)
   - Scale (temporal and spatial)
   - Appropriate approach (not one size fits all)
2. Gather relevant data and expertise
   - Review existing literature
   - Reach out to experts
   - Obtain/develop climate and ecological response projections

Considerations

- Level of specificity and complexity also relate to objectives and type of decision processes
  - Most complex not always the "best"
  - Potential for "false accuracy" when projecting at scales finer than data can bear
- Project management triad (can only maximize two of the three)
  - Time
  - Cost
  - Quality

Step 3

3. Assess components of vulnerability
   - Assess sensitivity, exposure, adaptive capacity
   - Estimate overall vulnerability
   - Document confidence levels/uncertainties

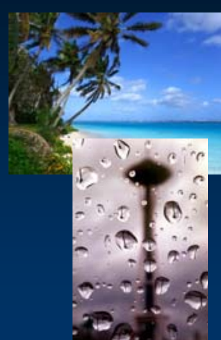
Sensitivity

Measure of whether and how a species or system is likely to be affected by a given change in climate

- Sunburn example:
  - Amount of melanin in skin is key physiological factor
  - Melanin absorbs UV rays, which cause sunburn
  - Skin with lower melanin levels is more sensitive to sunburn

Exposure

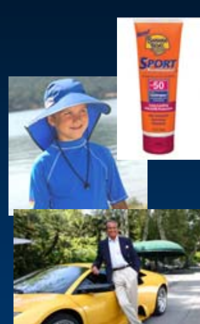
Measure of how much of a change in climate or other environmental factor a species or system is likely to experience



- Sunburn example:
  - The amount of UV rays determines exposure
  - Strength of rays depends on latitude, season & weather
  - With enough exposure, most anybody can burn

Adaptive Capacity

Ability to accommodate or cope with climate change impacts with minimal disruption



- Sunburn example:
  - Can be intrinsic (reduce sensitivity) or extrinsic (reduce exposure)
  - For sunburn, extrinsic adaptations includes sunblock, protective clothes, shelter
  - Intrinsic adaptations include UV-induced increase in melanin production (i.e., tanning)

Putting the Pieces Together

- Detailed modeling efforts
  - In-house or commissioned
- Vulnerability indices
  - e.g., NatureServe Index
- Expert elicitation
  - Supplement and/or supplant modeling

Addressing Uncertainty in Vulnerability Assessments

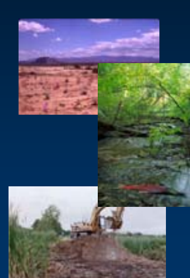
- Natural resource management has always faced uncertainty
  - Anxiety about uncertainty often leads to "analysis paralysis"
  - Don't deny it, embrace it
- Three types of uncertainty
  - Climate predictions
  - Ecological responses
  - Management effectiveness

Likelihood Scale

Terminology	Likelihood of the Occurrence/Outcome
Virtually certain	>99 percent probability of occurrence
Very likely	>90 percent probability
Likely	>66 percent probability
About as likely as not	33 to 66 percent probability
Unlikely	<33 percent probability
Very unlikely	<10 percent probability
Exceptionally unlikely	<1 percent probability

Step 4

4. Apply assessment results in adaptation planning
   - *Reduce sensitivity* (e.g., actively plant drought-tolerant species in area projected to get drier)
   - *Reduce exposure* (e.g., identify and protect cold-water refugia)
   - *Enhance adaptive capacity* (e.g., remove coastal armoring to facilitate habitat migration inland in response to sea-level rise



Using Assessment Results: An Example

Using Vulnerability Assessment Results to Inform Agency Decisions

The Massachusetts Division of Fisheries and Wildlife experience

Session Outline

- Focus on Massachusetts example
- A bit of background on our vulnerability assessment
- Focus on management, acquisition, regulation and monitoring
- Will use Red Brook Wildlife Management Area as an exercise
- Will talk about Regional Context
- Example exercise from the audience

My Project Goal

- To ensure that the wildlife conservation strategies detailed in the State Wildlife Action Plan (SWAP) are adapted for climate change impacts
- **Your Project Goal is to assess the vulnerability to climate change impacts of whatever is under your responsibility**

Adapting to climate change impacts will require doing our best to understand the factors that drive both the impacts and our ability to respond

In some cases, such as ocean acidification, there is no known adaptation option other than to reduce rates of change in GHG concentrations and climate

PITCH PINE-SCRUB OAK VULNERABILITY EVALUATION
NTWHCS category: Northeastern Interior Pine Barrens/North Atlantic Coastal Plain Pitch Pine barrens
State ranking S2
Vulnerability score 4 (both emissions scenarios)
Confidence evaluation Low[sb1]
Rationale Its range extending south to New Jersey and Maryland, this community type reaches its northern limit on sandy, nutrient-poor, drought-prone soils in southern Maine, on Cape Cod, in the southern part of the Massachusetts coastal plain, and in the Connecticut River Valley (see Massachusetts Natural Heritage and Endangered Species Program map below). It is therefore a southern community type that extends into southern and central New England. Its canopy is dominated by Pitch Pine, with an understory of Scrub Oak, Huckleberry, and Lowbush Blueberry. The system is fire-maintained and will revert to White Pine or oak-dominated forest in the absenceof fire (NHESP, 2007).

Figure 1. Distribution of Pitch pine-scrub oak communities in Massachusetts.
Pitch pine-scrub oak occurs in significantly warmer climates to the south in New Jersey and Maryland. If the only determinant of its distribution were climate, it would be likely that its distribution in Massachusetts would extend under a warming climate. However, non-climatic factors, mainly the distribution of sandy, nutrient-poor soils; fire frequency; and development, are also important factors. These are likely to be the main limiting factors in any future spread of pitch pine barrens, not climate change. Based on this, a vulnerability score of 4 (extent of habitat may not change appreciably under climate change) has been assigned for both scenarios. The confidence score that we assign for this community type is Low. This is because its future distribution is dependent on uncertain human settlement patterns and responses to climate change. Urban development is already a major fragmenting factor affecting this forest type and it is unlikely that this pressure will ease over the next few decades. Also, as the summers warm and droughts become more frequent and prolonged, fire outbreaks may become more frequent and/or intense. How humans respond to this is a major uncertainty. If the societal response is increased fire suppression (to protect property and lives), it could result in further loss and fragmentation of this habitat type.

Using the Vulnerability Assessment Results

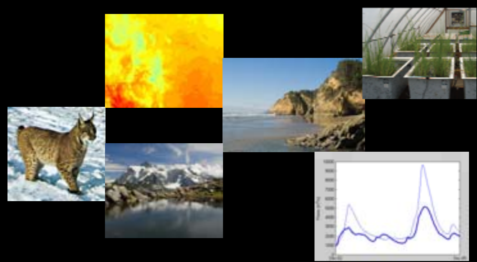
- Management: Develop site Management Plans for a limited number of Wildlife Management Areas
- Acquisition: Add results of the Vulnerability Assessment under threats in existing land acquisition process
- Regulation: Climate change impacts may require changes to existing regulations. Examples include: intermittent versus perennial stream designation, allowed wetlands protection measures
- Monitoring: Working with USGS to develop a plan that will include wetlands and other aquatic habitat types

In Summary

- Searches for adaptation solutions should consider consequences both for multiple sectors and for the short and the long term.
- In addition, a comprehensive understanding of the psychological, social, and political obstacles to adaptation is required, as well as an understanding of how to overcome them.
- Failure to do so frequently increases both vulnerability to climate change and the costs of adaptation over the longer term; it may also reduce incentives to explore more effective long-term solutions.

Regional Context

- Northeast Association of Fish and Wildlife Agencies Regional Conservation Needs
- U.S. Fish and Wildlife Service Landscape Conservation Cooperatives



Unit 2. Elements of a Vulnerability Assessment

Goals

<u>Goal 1.</u> Be able to identify, recognize, and discuss the different components of vulnerability and how they are measured (scientific basis).

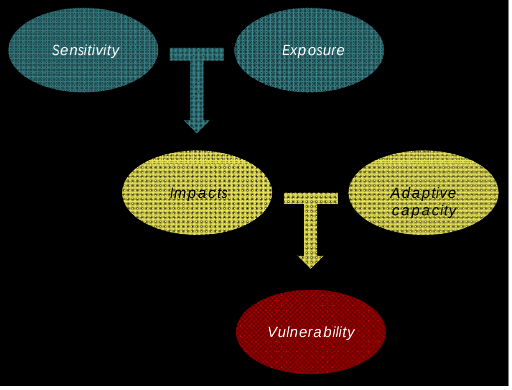
<u>Goal 2</u>. Recognize how to assess those components by comparing the data, tools, and models used in the assessment.

Vulnerability

Sensitivity – the degree to which the persistence or functioning of a species or system is dependent on climate or factors driven by climate

Exposure – the magnitude of the change in climate or climate driven factors that the species or system in question will likely experience

Adaptive capacity – the degree to which a species or system can change or respond to address climate impacts



Sensitivity

Sensitivity of species

Species' Sensitivities to Climate Change

- Physiological sensitivity
- Sensitive habitats and disturbance regimes
- Interspecific interactions
- Location and range
- Phenology
- Additional stressors

Sensitivity of Ecological System

System sensitivities to climate change

- Climate breadth
- Individual species sensitivities
- Disturbance regimes
- Other stressors

System sensitivities: Examples

Activity 1. Assessing sensitivity

Unit 2: Presentation 2

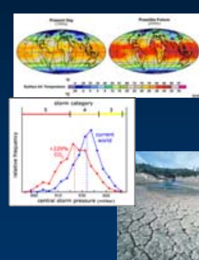
Assessing Exposure

Patty Glick
National Wildlife Federation

Exposure

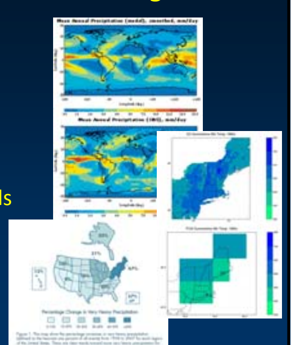
Measure of how much of a change in climate or other environmental factor a species or system is likely to experience

- Exposure to *Climate Change*
  - Shifts in temperature, precipitation (i.e., “basic climate”)
- Exposure to *Associated Impacts*
  - For example, sea-level rise; hydrologic changes; changing fire regimes; changes in CO_2 concentrations; changes in storm frequency/intensity



Exposure to *Climate Change*

- Global climate models
  - General Circulation Models (GCMs)
  - Atmosphere-Ocean General Circulation Models (AOGCMs)
- Downscaled climate models
  - Statistical approach
  - Dynamical approach
- Historical data
  - Observed trends



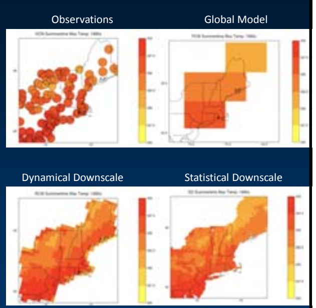
Global Climate Models 101

Global climate models generate projected changes in climatic variables (e.g., average temperatures, precipitation) based on one or more scenarios for emissions of greenhouse gases, particulates, other factors

- Factors to consider
  - Uncertainties in scenarios (depend on policy, economics, population, etc.)
  - Some models more successful than others at reproducing observed climate and trends over past century
  - Confidence in results often higher in nearer term, also higher for temperatures than precipitation

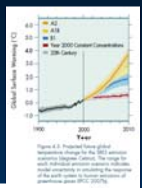
Is Downscaled Information Necessary?

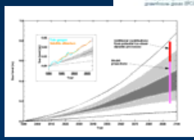
- Factors to consider
  - Scale of area being managed
  - Complexity of area being managed
- Downscaling methods
  - Dynamical
  - Statistical
- Benefits and limitations
  - Data often more relevant for management scale
  - Not necessarily more "accurate"



Which Scenarios to Use?

- Factors to consider
  - Length of your planning horizon
  - Sensitivity of key species or processes (helps ID variables to consider)
  - Level of confidence in projections
  - Level of acceptable risk
- Level of detail
  - Specific numbers
  - A range of numbers
  - Directionality



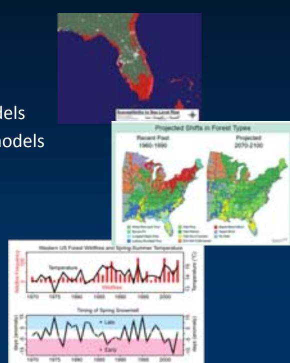


Tools/Resources for Relevant Information

- ClimateWizard
  - www.climatewizard.org
  - Developed by The Nature Conservancy, the University of Washington, and the University of Southern Mississippi
  - Enables technical and non-technical users to assess historical and projected climate change information
- DOI Climate Science Centers (CSCs) and Landscape Conservation Cooperatives (LCCs)
  - CSCs will deliver basic climate impact science to LCCs
  - LCCs will link science with conservation delivery

Exposure to *Associated Changes*

- Response Models
  - Conceptual models
  - Hydrological models
  - Habitat response models
  - Climate “envelope” models
  - Ecological models
- Historical data
  - Observed trends
  - Response to disturbances

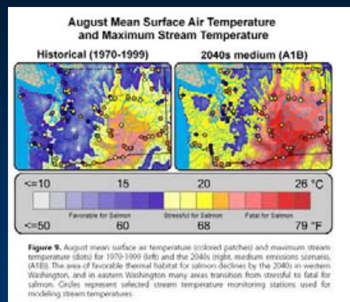


Considerations for Response Models

- Choice of models
  - Depends on the species, habitats, ecosystems of concern (including scale)
  - Depends on the types of questions being asked
  - Depends on end-user’s needs
- Limitations of response models
  - Overly-simplified (e.g., may ignore factors such as interactions between species; nonlinear, complex responses; other factors)
  - Data availability varies
  - Transferability across regions and scales

Example: Exposure to *Air and Water Temperatures*

Exposure analysis for assessing vulnerability of salmon to climate change (salmon are sensitive to water temperatures)



Example: Exposure to *Sea-Level Rise*

Exposure analysis for assessing vulnerability of coastal wetlands to sea-level rise (wetlands are sensitive to tides/elevation)

- Initial Condition
- 11.2-inch SLR
- 27.3-inch SLR
- Diked areas

Break-out: Assessing Exposure

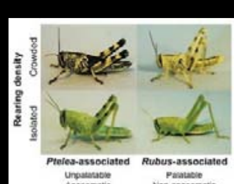
Adaptive capacity

"the potential, capability, or ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC 2007)

Adaptive capacity

- Genetic variability
- Phenotypic plasticity
- Behavioral plasticity
- Dispersal abilities
- Landscape permeability

Adaptive capacity



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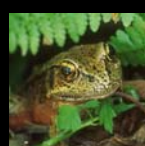

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Adaptive capacity

- Genetic variability
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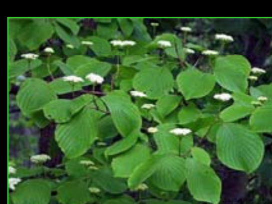
Genetic Variability

Concord, Mass.

Plasticity

Melilotus officinalis



Cornus rugosa

Dispersal

Adaptive Capacity: Communities

Intrinsic vs. extrinsic

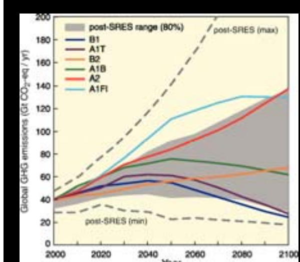
Extrinsic adaptive capacity: management potential

Activity 3. Adaptive capacity

Amphibian response to climate change in the southeastern US: A model for identifying priorities

Kyle Barrett, Nathan P. Nibbelink, John C. Maerz
Warnell School of Forestry and Natural Resources
University of Georgia

Uncertainty is ubiquitous



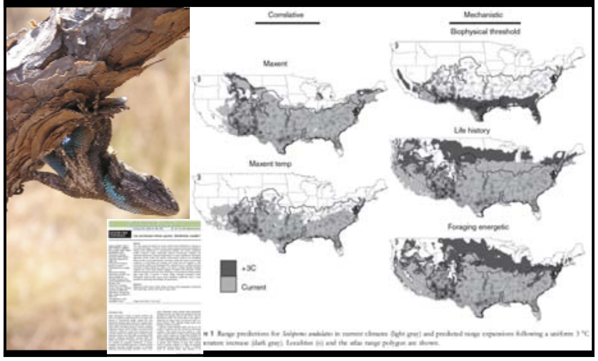
- Conservation decisions must be made now – prior to perfect information
- "Judicious use of model projections at appropriate scales may help us prepare[1]"

1Wiens, J.A. and D. Bachelet. 2011. Cons Bio 24:51-62

What approach do we take, and at what scale?

- Climate change is a large-scale threat that requires a large-scale approach
- Action plans should be data-driven
  - Experimentation
  - Models

Methods for modeling species responses to climate change



So many problems, so little time

- The southeast represents one of the world's most diverse region for amphibians
  - Nearly 200 species
  - > 50 endemics
- Climate change is likely to result in a loss of climatically suitable habitat for many of these species

Prioritizing model effort: Expert solicitation

- Surveyed state herpetologists to identify priority species
- Identified results most relevant to wildlife managers

Climate change vulnerability assessment: target species

Salamanders	Frogs
Ambystoma cingulatum (2)	*Hyla andersonii (2)*
Ambystoma tigrinum	*Lithobates capito (3)*
Amphiuma pholeter	*Lithobates okaloosae*
Aneides aeneus (5)	*Lithobates sylvaticus*
Cryptobranchus alleganiensis (3)	*Pseudacris brachyphona*
Desmognathus aeneus (3)	*Pseudacris ornata*
Desmognathus welteri	
Desmognathus wrighti	
Hemidactylium scutatum (2)	
Necturus alabamensis	
Notophthalmus perstriatus (2)	
Plethodon ventralis	
Plethodon websteri (2)	
Plethodon wehrlei (2)	
Plethodon welleri	

Location of selected species

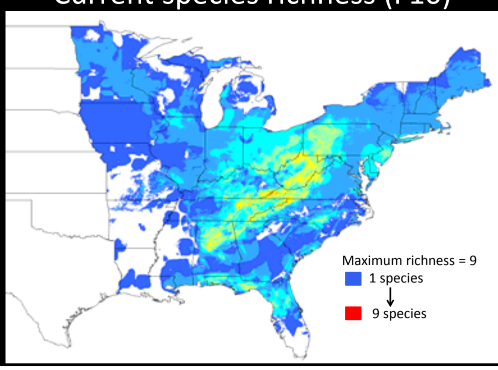
Building a correlative model

- Collected locality data from HerpNet and state-managed collections
- Background points limited to buffered species range
- Selected 12 ecologically relevant bioclim variables
- Used Maxent to construct habitat suitability models
- Examined species richness and individual species projections
  - A2a and B2a scenarios x 2 GCMs = 4 outcomes
  - Examined 3 thresholds per outcome
  - Generated ensembles of threshold and GCM

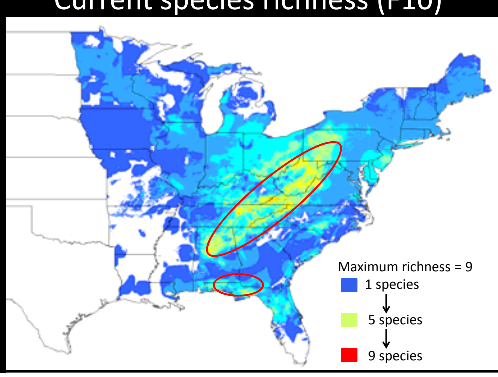
Building a correlative model
Output

- Examined species richness and individual species projections
  - A2a and B2a scenarios x 2 GCMs = 4 outcomes
  - Examined 3 thresholds per outcome
  - Generated ensembles of threshold and GCM

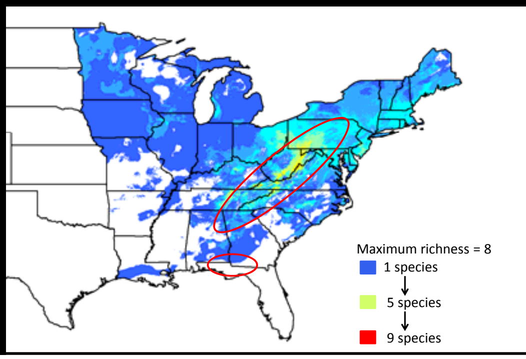
Identifying sensitive areas
Current species richness (F10)



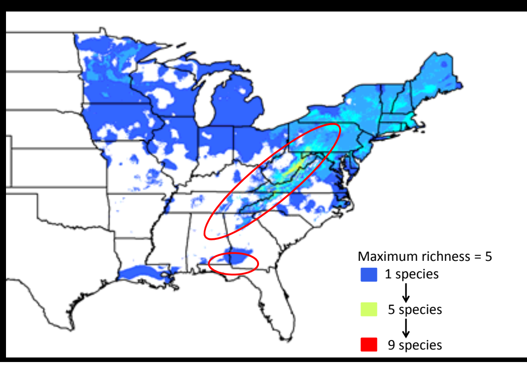
Identifying sensitive areas
Current species richness (F10)



Identifying sensitive areas
Hadley B2a 2020 species richness (F10)



Identifying sensitive areas
Hadley B2a 2050 species richness (F10)



Identifying sensitive species: species w/ 100% projected loss of suitable habitat

Species	Hadley						Canadian						# of "extinction" scenarios
	A2a			B2a			A2a			B2a			
	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	MTP	F10	MTR	
Ambystoma cingulatum	■	■	■	■	■	■	■	■	■	■	■	■	12
Lithobates okaloosae	■	■	■	■	■	■	■	■	■	■	■	■	12
Necturus alabamensis	■	■	■	■	■	■	■	■	■	■	■	■	12
Plethodon websteri	■	■	■			■	■	■	■	■	■	■	10
Plethodon ventralis	■	■	■	■	■	■				■	■	■	9
Amphiuma pholeter	■	■	■	■	■	■							6
Desmognathus wrighti	■	■	■	■	■	■							6
Lithobates capito		■	■			■		■	■			■	6
Desmognathus welteri							■	■	■			■	4
Notophthalmus perstriatus			■			■					■	■	4
Desmognathus aeneus										■	■	■	3
Hyla andersonii								■	■				2
Plethodon wehrlei									■				1
Plethodon welleri									■				1

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Plethodon websteri				0.98	0.98								10
Plethodon ventralis							0.97	0.97	0.95				9
Amphiuma pholeter							0.82	0.80	-1.56	0.99	0.99	0.89	6
Desmognathus wrighti							0.96	0.99	0.96	0.96	0.99	0.98	6
Lithobates capito	0.96			0.96	0.98		0.99			0.93	0.98		6
Desmognathus welteri	0.91	0.91	0.90	0.90	0.90	0.87				0.97	0.98		4
Notophthalmus perstriatus	0.96	0.99		0.93	0.99		0.97	0.94	0.79	0.99			4
Desmognathus aeneus	0.95	0.95	0.93	0.93	0.93	0.91	0.97	0.98	0.96				3
Hyla andersonii	0.83	0.83	0.83	0.87	0.92	0.93	0.98			0.94	0.95	0.98	2
Plethodon wehrlei	0.92	0.93	0.95	0.89	0.94	0.99	0.94	0.99		0.73	0.80	0.87	1
Plethodon welleri	0.81	0.96	0.99	0.74	0.90	0.99	0.96	0.99		0.86	0.95	0.97	1

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= Coastal Plain

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= Coastal Plain = Piedmont

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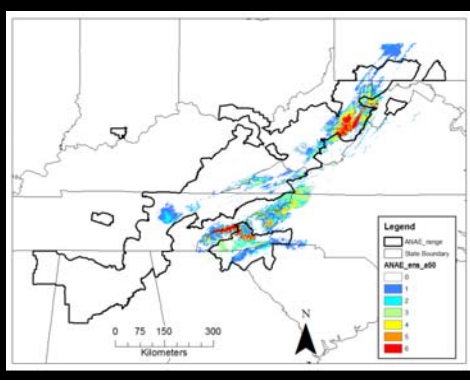
= Coastal Plain = Piedmont = Appalachian Mnts

Aneides aeneus – Ensemble A2a 2050



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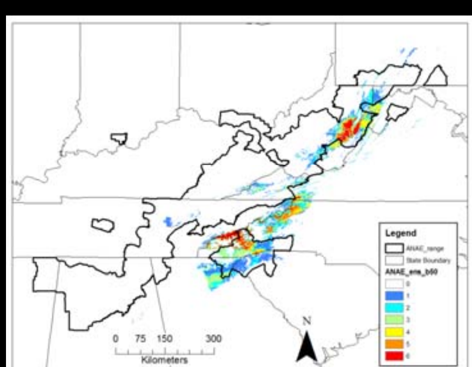
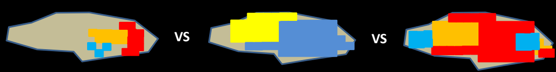


Prioritizing protected areas
(Identifying climate refugia for a species)

Primary Designation Type	Primary Designation Name	Area (ha)	B2a Percent	B2a Weighted Avg	A2a Percent	A2a Weighted Avg
		Alabama				
State Resort Park	Cheaha Resort SP	802	0.90	0.35	0.20	0.10
Wilderness Area (USFS)	Cheaha Wilderness	2,964	0.35	0.17	0.03	0.01
National Forest (USFS)	Talladega National Forest	162,802	0.01	0.00	0.00	0.00
		Georgia				
State Park	Don Carter SP	476	1.00	0.50	0.00	0.00
State WMA	Lula Tract WMA	499	1.00	0.50	0.00	0.00



Model summary

- Coastal Plain habitats shift in suitability as much as other hotspots (southern Apps)
- Over half of the modeled species are projected to lose* ≥ 90% of currently suitable habitat
- Individual species models can be ensembled
  - Identification of protected areas that may provide management opportunities
  - Quantification of uncertainty

Climate change and conservation planning

- Many conservation plans (state/fed) have a stated goal of incorporating climate change
- Downscaled models with ecologically-relevant predictors are essential
- Importance of uncertainty is recognized, but it is often considered difficult to incorporate
- Developing ensembled projections that distill uncertainty down to a few synthetic products will make it more user friendly

HABITAT VULNERABILITY ASSESSMENT

Hector Galbraith
Manomet Center for Conservation Sciences

EXPERT ELICITATION IN VA – THE NEAFWA MODEL

- The Northeast Association of Fish and Wildlife Agencies Regional Habitat Vulnerability Model
- Finalized 3 months ago
- Objective is to help map geographical variation in habitat vulnerabilities across 13 NE states
- Combination of Excel-based formal model and expert elicitation

THE NEAFWA MODEL - REGIONAL CONTEXT

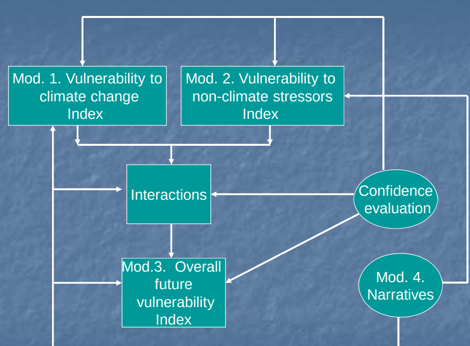
- Intended to scale-up to entire NE Region
- Regional Adaptation Strategy
- Regional context essential for effective decision-making
- Also provides individual states with preliminary VA

THE NEAFWA MODEL

Has six major elements:

1. Module 1. Assessment of vulnerability to climate change
2. Module 2. Assessment of vulnerability to non-climate stressors
3. Module 2. Interaction potential
4. Module 3. Assessment of overall future vulnerability
5. All Modules. Confidence evaluation
6. Module 4. Narratives (transparency)

THE NEAFWA MODEL



NEAFWA MODEL EXPERT ELICITATION PROCESS

- Expert panel formed:
  - 40 participants from 13 NE states, feds and NGOs
  - Wildlife biologists, ecologists, habitat specialists, regulators
  - Given education in likely future climates in NE
  - Informed about how systems/species already reacting

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- First task of EP - to review and comment on draft model
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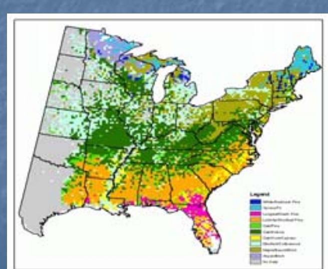
- Expert panels formed in fall 2010
- Draft model reviewed in winter 2010
- Model finalized – March 2011
- Workgroups - formed
- Model runs – summer 2011
- 12 habitat evaluations completed winter 2011/spring 2012

EXPERT ELICITATION – CRUCIAL ISSUES

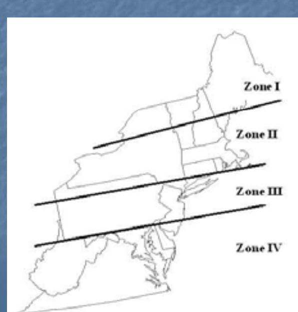
- Confidence evaluation – quantify
- Transparency – no smoke and mirrors!

Appalachian-Acadian Montane Spruce-Fir Forest

Appalachian-Acadian Montane Spruce-Fir Forest



NEAFWA ZONES

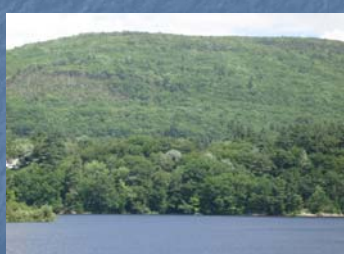


Appalachian-Acadian Montane Spruce-Fir Forest

Table 3. Vulnerability modeling results.

Zone	Vulnerability to Climate Change	Vulnerability to Non-climate Stressors	Overall Vulnerability	Certainty
Zone I	Vulnerable	Vulnerable	Vulnerable	High
Zone II	Highly Vulnerable	Highly Vulnerable	Critically Vulnerable	High

Northern Hardwood Forests



Northern Hardwood Forests

Northern Hardwood Forests

Table 2. Northern Hardwood Forest vulnerability modeling results.

Zone	Vulnerability to Climate Change	Vulnerability to Non-climate Stressors	Overall Vulnerabilit y	Certainty
Zone I	Less Vulnerable	Less Vulnerable	Less Vulnerable	High
Zone II	Vulnerable	Vulnerable	Vulnerable	High
Zone III	Vulnerable	Vulnerable	Vulnerable	High
Zone IV	Highly Vulnerable	Highly Vulnerable	Critically Vulnerable	High

Species Vulnerability Indices

Alternatives to “DIY”

Species are Important!

Vulnerability Indices can…

… save R & D time

… remind you about vulnerability factors

… compare apples and oranges

… promote transparency

Vulnerability Indices cannot...

... turn garbage into gold

... replace in-depth VAs of species

System for Assessing `Vulnerability of Species (SAVS) to Climate Change (Forest Service)

Framework for categorizing the relative vulnerability of threatened & endangered species to climate change (EPA)

Climate Change Vulnerability Index (NatureServe)

All:

are potentially rapid

score individual factors

produce categories of relative vulnerability

address uncertainty

SAVS

www.fs.fed.us/rm/grassland-shrubland-desert/products/species-vulnerability

Terrestrial vertebrates

Habitat, physiology, phenology, biotic interactions

Abundance, range, demographics considered implicitly

Scale: habitat/management area

EPA

http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=203743

T&E Vertebrates Only

Baseline & climate change vulnerability

Abundance, range, demographics considered in baseline

Spatial Scale: any

NatureServe

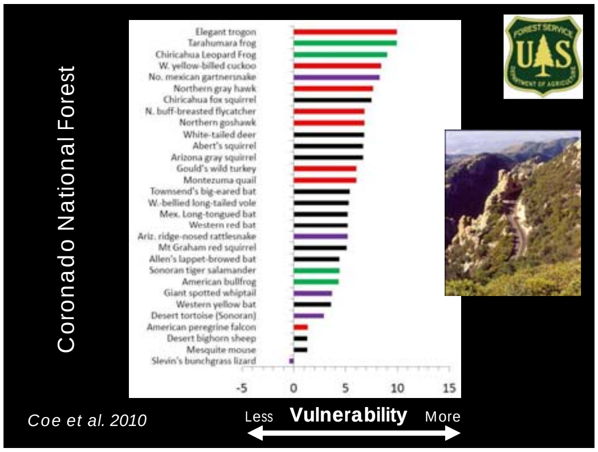
www.natureserve.org/climatechange

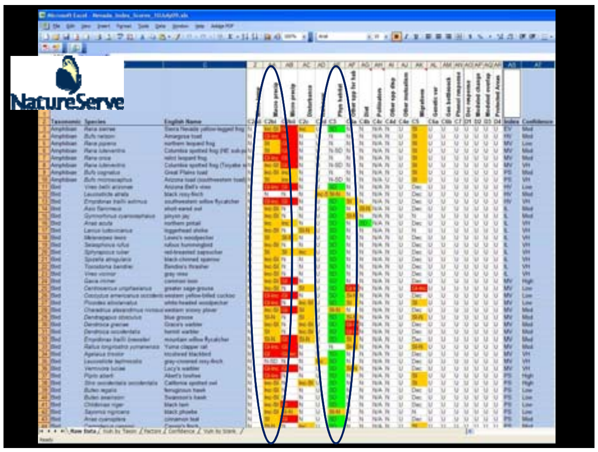
Terrestrial/aquatic, plants/animals

Excludes conservation status factors – use in conjunction with G/S-ranks

Exposure and sensitivity sections

Scale: state or large conservation area





Duplicate Conservation Status Assessments?

	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumed Stable	Increase Likely
G1					
G2					
G3					
G4					
G5					

NatureServe

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NatureServe

209 spp

	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumed Stable	Increase Likely
G1	10	11	25	9	0
G2	2	4	5	3	1
G3	0	4	3	11	1
G4	1	1	6	24	3
G5	0	2	7	61	15

$p<0.001$

NatureServe

EXPERT JUDGMENT AND ELICITATION IN VA

- All models rely on some degree of expert judgment
  - Climatic envelope models need best estimates of what comprises current climatic "range"
  - Deterministic models need judgments about (e.g.,) physiological tolerances
  - Judgments about resiliencies or adaptive capacities of organisms/habitats/processes

EXPERT ELICITATION APPROACHES

- Rely more heavily on expert judgments to project into future
- Can range from highly formal and controlled elicitation-based models and processes to less formal
- All may have merit, depending on how they were done
- Defensible? Depends on arena and for what purposes.

EXPERT ELICITATION APPROACHES

Long history in conservation and regulation:

- ESA – listing species and critical habitat designation (legally defensible)
- CERCLA – ecological risk assessment (legally defensible)
- NRDA – injuries to resources (legally defensible)
- State-level – identifying habitat acquisitions (not required to be legally defensible)
  - Instream flow assessment

WHY EXPERT ELICITATION APPROACH?

- Often do not have current data
- We are projecting into future – don't have "future data"
- Reservoir of detailed knowledge and expertise
  - ecology
  - current extents and change
  - threats
- "Ownership" and buy-in
- Relatively rapid with low resource costs

WHY EXPERT ELICITATION APPROACH?

- We may not have the luxury of a rain-check – answers needed, and fast!

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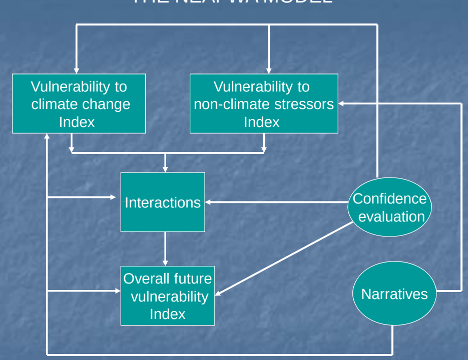

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UNCERTAINTY/TRANSPARENCY IN VA

Hector Galbraith
Manomet Center for Conservation Sciences

ORIGINS OF UNCERTAINTY IN VA

1. Uncertainty in climate models
2. Uncertainty in future emissions assumptions
3. Uncertainty in ecological response models
4. Uncertainty in geohydrological processes
5. Uncertainty in societal responses

ORIGINS OF UNCERTAINTY IN VA

- GCMs:
  - 26 different models
  - Differ in sensitivities from high (Hadley) to low (PCM)
  - Predictions vary from: much warmer and wetter (Hadley) to warmer and drier (PCM)

VARIATION IN GCM PREDICTIONS

Massachusetts, B1 emissions scenario

Hadley3:	+5-7F;	+10-15%precip
GFDL:	+2.5-5F;	+2-10%precip
PCM:	+2-3F;	<+10%precip

VARIATION IN GCM PREDICTIONS

Downscaling analyses have addressed GCM variability by:

- "Bounding" based on model sensitivities
- Means of two or more models
- Percentiles

UNCERTAINTIES IN DOWNSCALING

- Availability of ground-station data for statistical downscaling
- Beware spurious accuracy and precision

FUTURE EMISSIONS RATES

B1: doubling of GHGs by 2100
A1FI: tripling of GHGs by 2100

Massachusetts Hadley3 model:
B1: +5-7F by 2100
A2: +6-8F by 2100

FUTURE EMISSIONS RATES

Most analyses "bound" using optimistic and less optimistic scenarios (B1, AIF1/A2)

UNCERTAINTY IN RESPONSE MODELS

- How ecosystems/species will respond to cc uncertain (physiological tolerances, resilience, adaptive capacity, management potential)
- Uncertainty in aquatic/wetland systems
  - Future precipitation patterns
  - Geohydrologic changes
  - ecoresponses

UNCERTAINTY IN SOCIETAL RESPONSES

- Beneficial responses?
- Maladaptive responses (sea walls, fire control, responses to invasives)?

SOURCES OF UNCERTAINTY - SUNMMARY

- Uncertainty for every component (climate and eco modeling)
- Will not go away! (tightening up the climate models would be terrific, but not a silver bullet)
- We need to move forward despite uncertainties

OPTIONS FOR HANDLING UNCERTAINTY IN VA

Range from quantitative to rank-based:

Simulation (Monte-Carlo) analysis

- Assumptions about probability distributions in variables
- Not all variables have amenable distributions (e.g., management potential)
- We just don't know!
- Spurious accuracy and precision?

OPTIONS FOR HANDLING UNCERTAINTY IN VA

- Scenario planning (if this, then that)
- Monitoring is critical

T&S SPECIES AND NEAFWA APPROACH

Uncertainty ranking based on IPCC approach

Variable scores assigned one of three certainty scores (high, medium, low)

High - >70%
Medium – 30-70%
Low - <30%

T&E FRAMEWORK

Two methods used:

- Certainty of each variable scored and total combined into Total Certainty Score (H,M,L)
- Alternative certainty scores for each variable and 3 TCS:
- Best estimate is Vulnerable, but could (though less likely) range from Highly Vulnerable to Vulnerable.

NEAFWA MODEL

- Each variable scored (H,M,L)
- Variable scores combined into Total Certainty Score.

Benefits of T&E/NEAFWA approaches:

- Allow us to identify where greatest sources of uncertainty lie
- Allow regulators/planners to assess likely effectiveness of specific actions.

TRANSPARENCY IN VA

- Reviewers/users of VA need to be able to “connect the dots”
- How scores arrived at must be made transparent
- Uncertainties and how they were handled must be acknowledged
- Different VA models vary in their transparencies
- Narratives

MIGRATORY WILDLIFE VULNERABILITY ASSESSMENT

- Migratory wildlife introduce difficult challenges for VA:
  - Highly extravagant lifestyles
  - Where? Breeding range, wintering range, stopover sites, migration itself, all of above?
  - Synchronicity?
  - Data hard to come by from parts of range

RED KNOT - SUPERMIGRANTS

RED KNOT MIGRATION AND STOPOVER SITES

RED KNOT – WHERE ARE THE VULNERABILITIES?

- Tierra del Fuego?
- Argentina coast?
- Brazil?
- Mid-Atlantic states?
- Hudson's Bay?
- High Arctic?
- Fall or spring?
- Wind patterns?
- Synchronicities?

Comprehensive VA needed

Vulnerabilities of Shorebirds to Climate Change

Hector Galbraith[1], Stephen Brown[1], David W. DesRochers[2], J. Michael Reed[3]

[1]Manomet Center for Conservation Sciences
[2]Dalton State College
[3]Tufts University

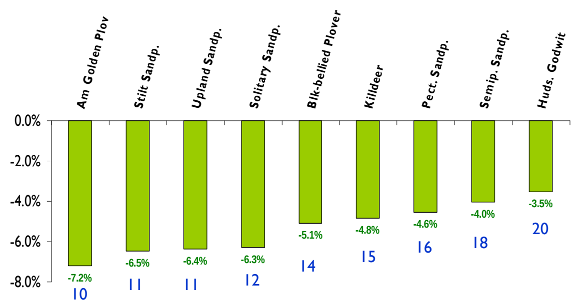
Objectives

- Evaluate potential change in extinction risk of North American shorebirds due to climate change
  - directly due to effects of climate change
  - not those due to changed human activities associated with climate change

Why Shorebirds?

- Reported widespread declines
- Proposed to be sentinels of global environmental change – particularly because of their hemispheric ecosystem use during life cycle (Brown et al. 2001; Piersma & Lindström 2004)
- Migratory aggregations of some species are a spectacular biological phenomenon
- Iconic species valued by public?

SHOREBIRDS ARE IN TROUBLE



Based on migration counts in eastern N. America; Bart et al 2007. *J Av. Biol*

Our Approach

- Evaluates threats to shorebirds by species
- Works within the context of the Partners-in-Flight & U.S. Shorebird Conservation Plan risk systems
  - based on population size & trend, breeding & non-breeding distributions, threats to breeding & non-breeding sites

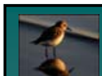
http://www.outdooralabama.com/watchable-wildlife/what/Birds/shorebirds/rt.cfm

MAIN QUESTIONE ASKED

- How much does climate change move the needle on the existing vulnerability categories of USCP/PIF?

U.S. Shorebird Conservation Plan Risk Categories

1) Not at Risk
2) Low Concern
3) Moderate Concern
4) High Concern
5) Highly Imperiled
6) ~~Holy Smokes! Really, highly imperiled~~ Critical



Vulnerability Factors

	Score	Arrow
1) Loss/gain in breeding habitat under climate change	3	↑
2) Loss/gain in wintering habitat under climate change	5	↑↑
3) Loss/gain in migration habitat under climate change	3	↑
4) Degree of dependence on ecological synchronicities	5	↑↑
5) Migration distance	4	↑
6) Degree of breeding, wintering, or migration habitat specialization	4	↑↑

http://www.wilddelaware.com/2008/05/

Risk Factors

1) Loss/gain in breeding habitat under climate change:	Score	Arrow
Major loss (>50%)	5	↑↑
Moderate loss (10-50%)	3	↑
Limited or no loss (-10-10%)	0	0
Moderate increase (10-50%)	-1	↓
Major increase (>50%)	-2	↓↓

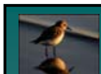
Note: risk could decrease

Example: Semipalmated Sandpiper

1) Loss/gain in breeding habitat under climate change:	Score	Arrow
Moderate loss (10-50%)	3	↑

Yearlong rainfall predicted to ↑ throughout breeding range. May result in flooding & loss of much breeding habitat especially since the species prefers drier areas with access to water. Nesting habitats along shorelines also could ↓ as a result of increased rainfall.
Confidence = low

http://www.birdsireland.com/pages/rare_bird_news/2006/september_photos1.html



Semipalmated Sandpiper

	Score	Arrow
1) Loss/gain in breeding habitat under climate change	3	↑
2) Loss/gain in wintering habitat under climate change	5	↑↑
3) Loss/gain in migration habitat under climate change	3	↑
4) Degree of dependence on ecological synchronicities	5	↑↑
5) Migration distance	4	↑
6) Degree of breeding, wintering, or migration habitat specialization	4	↑↑

Change in status from ‘moderate concern’ to ‘highly imperiled’

http://www.wilddelaware.com/2008/05/

Application

- Evaluated 49 species of shorebird breeding in North American north of Mexico
- For each factor, included confidence level
- Summed arrows
- Determined shifts in risk category

Results for 50 North Am. Shorebirds

- 43 species (86%) predicted to ↑ risk level due to climate change
  - 34 increased by 1 level
  - 9 increased by 2 levels
- 3 species at lower risk
  - Solitary sandpiper – more breeding habitat
  - Bristle-thighed curlew – more breeding & wintering habitat
  - White-rumped sandpiper – more wintering habitat

http://www.scvas.org/index.php?page=babp&id=glentepke2

U.S. Shorebird Conservation Plan

Risk Category	Current	Expected with climate change
Not at risk	0	0
Low concern	7	2
Moderate concern	15	7
High concern	23	13
Highly imperiled	4	17
Critical	–	10

Species in New 'Critical' Category

- Snowy Plover
- Wilson's Plover
- Piping Plover
- Mountain Plover
- Am. Oystercatcher
- Long-billed curlew
- Bar-tailed godwit
- Ruddy turnstone
- Sanderling
- Short-billed dowitcher

http://nationalzoo.si.edu/scbi/MigratoryBirds/Featured_photo/photographer.cfm?photographer=Gerhard_Hofmann

Where from here?

- Species-specific risk assessment
- ID common risks as focus for management activity
  - e.g., shoreline habitat on migration routes & wintering areas
- Still reviewing the assessments & considering degree of threat to shift risk category
- We welcome feedback, things to consider, insights, information

http://www.naturspesialisten.no/article.php?id=473&p=

TAKE HOME MESSAGES

- For complex spp. We need complex, comprehensive VA
- They are doable
- Build off of existing structures if possible (PIF, NAWP, etc.)
- Must be resilient to lack of data

Unit 4. Building a vulnerability assessment

Defining objectives and scope

Identify:

Audience
Requirements
Needed products

Resource mangers
Upper-level managers
Policy makers
Scientists
Educators
Industry
General public

… in an ideal world

Identify:

Audience
Requirements
Needed products

T&E species management
Energy infrastructure siting
Resource management
Land acquisition
Land-use policy creation
Zoning
Infrastructure maintenance

… in an ideal world

Identify:

Audience
Requirements
Needed products

Maps of sea-level rise
Most vulnerable places
Species at greatest risk
Population projections (PVAs)

… in an ideal world

… but in the real world:

Engage key stakeholders

Establish goals and objectives

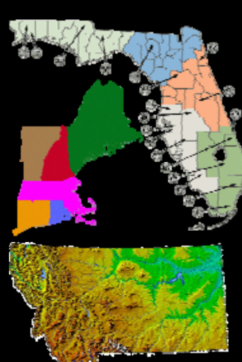
Identify assessment targets

Determine spatial and temporal scale

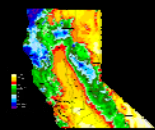
Spatial extent

Spatial resolution

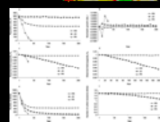
Time frames



Select assessment approach



Methods



Tools

Timeline

What we think you want to know *(but may not tell you)*

- What tools, processes, or approaches are best for helping me move forward?
  - Who to engage
  - How to engage them
  - What information/data I need and where to get it
- What are the best practices?
- What are the pitfalls to avoid?

Two key principles for choosing data and tools

1. Your goals and objectives should drive the selection of tools and data, not vice versa
2. The sophistication of the VA should not exceed the sophistication of possible uses of VA results.

Choosing tools and data comes back to the basic questions:

- *What is the goal of your VA?*
  - *"Assessment questions": what do you need to know to answer them?*
- *Who will use the output and how?*
- *What resources do you have?*

If you don't ask the right question, every answer feels wrong
Ani DiFranco

Goal/question?

- Educate/engage
- Rethink conservation management goals/objectives
  - Is my work at risk? How serious is the risk?
- Initiate/develop adaptation plans
  - Where should I focus adaptation effort?
- Integrate climate change into existing guidelines, processes, etc.
  - How can I maximize my effectiveness?

Who and how?

- <u>What do they do?</u> Recovery plans, culvert design, funding allocation, etc.
- <u>Group dynamics</u>: Established, (dys)functional group or new group?
- <u>Existing decision-making</u> (quantitative? data-driven? Structured? etc.)
- <u>Where they are relative to climate change</u> (ready to make decisions, needs more capacity-building, etc.)
- <u>Your relationship with them</u> (one workshop → long process)

Resources?




Answering these questions helps you determine…

- *Scale*
- *Assessment target (species, location, management actions, etc.)*
- *Type of stakeholder engagement*
- *Decision framework*

…which in turn tells you what to look for in tools…

- *Quantitative to qualitative*
- *Context-driven or data-driven*
- *Complex models to transparent processes*
- *Descriptive or prescriptive*

…and data sets

- *Key drivers of vulnerability for your target*
  - *Specific climate variables*
  - *Critical species, community, and ecosystem characteristics*
  - *Important interacting stressors*
- *Necessary spatial and temporal resolution*
- *Necessary level of precision*

Types of data/information

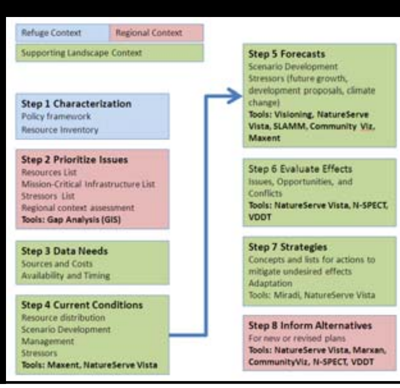
- Observations
- Models
- Experiments
- Expert opinion

- Tells you what but not why; integrates all factors; varying degrees of sophistication
- Represents current understanding of system; simplifies complexity; can create false sense of accuracy/certainty
- Tests causal links; limited number of variables tested at a time.
- Good when there is limited "hard" data; varying levels of structure and sophistication

You don't have to pick just one!

- Can use different tools and data at different points in the VA and adaptation planning process

NatureServe Refuge VA Framework



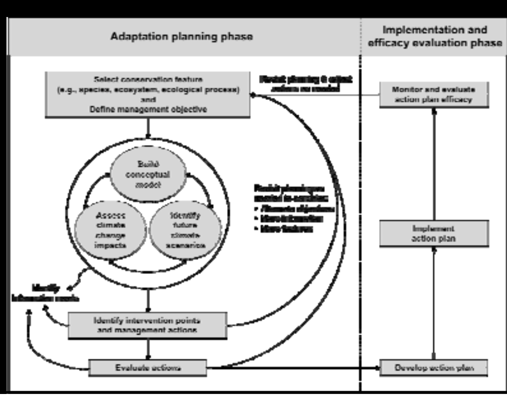
VAs in the context of adaptation planning:

The ad hoc adaptation planning working group

A range of approaches

- Qualitative to quantitative
- Climate-centric vs. climate-integrated
- Endpoint/goal of process
- Tools/models used (if any)
- Scale (time, space, sectors, complexity)
- Audience (focus, diversity)

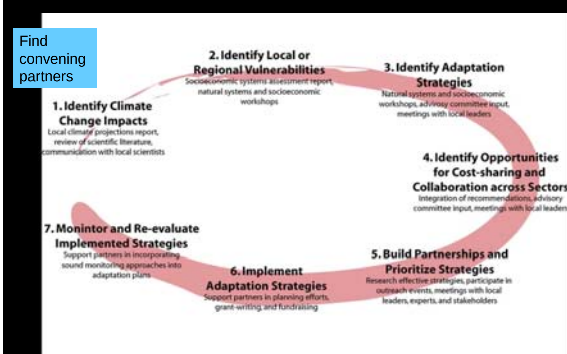
Adapting Conservation Targets (ACT) Framework



TNC: Updating a conservation action plan

1. Understand potential ecological impacts.
2. Create and revise "hypotheses of change."
3. Explore human responses.
4. Prioritize among climate-induced threats.
5. Assess whether climate change fundamentally changes the project.
6. Update or create strategies, assess feasibility and cost, re-prioritize full set of project strategies.
7. Develop measures, implement, adapt, learn

Geos ClimateWise

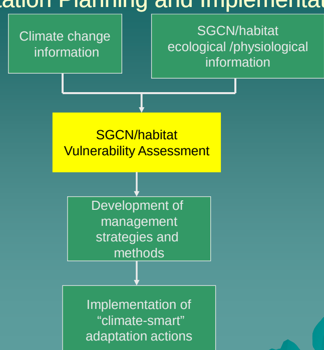


EcoAdapt A2A

- 4 basic questions:
  - What is your goal?
  - How are you trying to achieve it?
  - How might climate change affect your likelihood of success?
  - How can you increase your likelihood of success given these realities?
- If workshop goal is actual action, ask about
  - Key partners
  - Key resources
  - Step-by-step timeline, including who will do what
  - Assessing success

Unit 5. Application of Vulnerability Assessment

Vulnerability Assessment is Essential Component of Adaptation Planning and Implementation



Vulnerability Assessment is Essential Component of Adaptation

Central adaptation question: how to allocate limited resources to meet real challenges and avoid poor investment decisions?

- Which ecosystems/species/sites are vulnerable to cc?
- Which ecosystems/species/sites may benefit or be unaffected?
- Which systems/species can be managed under cc?
- How will systems change – time line?
- State and regional vulnerabilities?

Vulnerability assessment is focusing process for adaptation – the road to adaptation lies through VA.

Application of Vulnerability Assessment

- Can be stand-alone (e.g., to support listing)
- Most valuable as a stepping stone to adaptation action:
  - Removal of a threat
  - New management actions
  - Changes to existing management actions
  - Acquisition of new lands
  - Planning monitoring strategies
  - Allows us to begin planning for change, rather than stasis

Application of Vulnerability Assessment

Threat amelioration:

- VA allows us to identify (and ameliorate?) existing stressors that reduce system/species resilience
- Allows us to assess the relative importance of climate and non-climate stressors
- Allows us identify systems/species that will *benefit* from cc
- Allows us to identify potentially maladaptive responses

Application of Vulnerability Assessment

Management of habitats/species:

- VA helps us understand which current management actions will "work" under cc
- Helps us identify and formulate new management options
- Helps us plan for the future

Application of Vulnerability Assessment

Identify potentially maladaptive responses:

- Armoring coastlines
- Water draw-downs

Application of Vulnerability Assessment

Management of habitats/species (examples):

- White-tailed deer in Northeast
- Forest stand age structure
- Management of “doomed” habitats/species

Application of Vulnerability Assessment

Acquisition of new holdings:

- Is it worth allocating scarce resources to habitats/species that will become more abundant?
- Is it worth allocating scarce resources to habitats/species that are “toast”?
- Is it worth allocating scarce resources to habitats/species that may be “safe” in another part of the region?

BEYOND SCORING VULNERABILITIES - USE OF VA IN ADAPTATION PLANNING

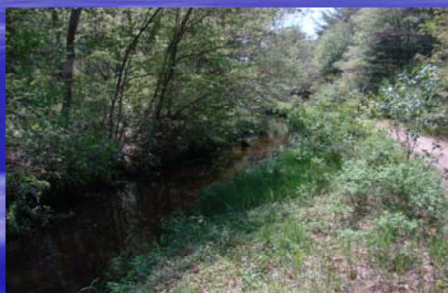
CENTURY BOG, MA

- Currently working cranberry bog
- Has valuable wildlife habitats in southeastern MA:
  - Cold water stream
  - coastal plain pond

State acquired site in 2010 because completes portfolio of acquisitions in this area

CENTURY BOG

CENTURY BOG



CLIMATE CHANGE VULNERABILITIES

Two of most valued habitats at CB highly vulnerable to CC:

- Cold water stream habitat
- Coastal plain pond

Vulnerability assessment identifies these as particularly threatened

ADAPTATION AT CENTURY BOG

VA also helps us focus and plan adaptation actions:

- Relocation of stream
- Shading of stream
- Punching holes into aquifer
- Water control in pond

BEYOND VA

- VA was originally important in identifying habitat vulnerabilities
- VA is now acting as important tool in planning climate-smart restoration at site.

Exercise 4.1: Building your own VA
CCVA Training Course

For the purposes of this exercise, we would like you to develop a plan for carrying out a vulnerability assessment using the key steps from *Scanning the Conservation Horizon*. Below are some questions to help you walk through the planning process; refer to the book for details and inspiration. Feel free to adjust this process as appropriate for your group, however (e.g. following a Statement of Work or Process Outline template from your agency).

1. **Goals and objectives**
   - **a.** What are your overarching, “big picture” goals and objectives related to this VA (e.g. improving the health of a particular watershed; ensuring the survival of a particular species)?

   - **b.** What are the goals and objectives of this particular VA effort (e.g. informing agency acquisition or investment priorities; selecting appropriate management measures; developing management plans for species or reserve; informing ESA listing decisions)? Address at least the following:

     - What motivated you to do a vulnerability assessment, and why now?

     - What specific decision(s) will be informed by this VA, and who has the power to make the decision(s)?

     - What would make you feel successful at the end of the assessment?

2. **Scope**
   - **a.** Identify your audience, user requirements, and needed products

     i. Who will use the results of your VA?

     ii. How will they use the results—when, in what form, and how often? To inform what decisions, and what’s their decision-making process?

b. Given your goals, objectives, and audience, identify suitable assessment targets--populations? Species? Management unit? Ecoregion? Management plans?

c. Given your goals, objectives, and audience, determine appropriate spatial and temporal scales

i. On what scales do key population, community, and ecological processes operate?

ii. On what scale do key management, regulatory, and funding processes operate?

3. **Information:** What information do you need to carry out a VA that will meet your goals and objectives? Below are some broad categories of information to consider (although they may not all be relevant). For each, think about specific information or areas of expertise you'd like, the relative importance of different types of information (e.g. desirable vs. essential), how to address and document gaps and uncertainties.

   a. ***Species, habitat, or ecosystem*** information (sensitivity, adaptive capacity)

   b. Historic, current, and future ***climatology***, focusing on ecologically relevant variables and suitable spatial and temporal scales (exposure)

   c. Historic, current, and future ***responses*** of species, communities, or ecosystems to climatic change (sensitivity, adaptive capacity)

   d. ***Key threats*** to your VA target beyond those linked to climatic change, and possible interactions between those threats and projected changes (exposure, sensitivity, adaptive capacity)

   e. ***Regulatory/management contex***t (mandates, laws, planning cycles, etc. that might influence both the VA process and the actual vulnerability of your assessment target)

4. **Resources other than information.** Think broadly: consider skills, funding, materials, infrastructure, permits, etc.

5. **Partners.** Who needs to be engaged in this effort, and at what stages and levels of engagement, for you to meet your goals and objectives? Whose support is essential for a VA that is both accurate and perceived as valid by users? If you don't know of the right partners off-hand, how might you go about identifying them? Consider:

   a. Partners who have important resources (data, influence, funding, time, resource knowledge).

   b. Partners important for making plans actually happen, providing credibility, etc.

6. **Tools and approaches.** Given your objectives, targets, users/partners, and available resources, what general approaches make sense? Are there tools that would facilitate your VA process? Consider various balances of expert opinion, published data, traditional knowledge, or new modeling/data collection.

7. **Synthesis, dissemination, and use.** Think back to your goals and objectives: what sort of outputs are you hoping for at the end of all this? Are there ways for you to shape your VA (e.g. target, partners, tools, approaches, etc.) that would increase the likelihood of your VA being used and your objectives being met? What do you need beyond simply your assessment results to feel successful?

    a. Who will you want to inform about your VA results and why?

    b. How might you best share VA results with them? Consider different approaches for different audiences and needs.

8. Rough timeline: Given the steps you've outlined and the partners you've identified, what's a realistic timeline for making each step a reality? What steps can happen in parallel? Which steps are dependent on previous steps?

9. How will you **assess the success** of your plan?
    a. Assessment points and metrics during implementation.

    b. Assessment points and metrics following implementation.

Greater Sage Grouse (*Centrocercus urophasianus*) and Humboldt-Toiyabe National Forest

Contents

Exercise 2.1: Assessing sensitivity

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group
Output: Sensitivity checklist

We want you to gain experience identifying and articulating components of sensitivity for species, habitats, and ecosystems. You may find yourself distracted by the question of whether a particular characteristic is a component of sensitivity, exposure, or adaptive capacity; in the end it doesn't matter which bin you put characteristics into. What matters is that you understand how particular characteristics contribute to vulnerability or the lack thereof.

Steps:

I. You will be working in groups of 6-8 people around a table. Each table will have a packet of information for Exercises 2.1, 2.2, and 2.3. This packet will include a variety of maps related to a particular species and administrative unit.
II. Examine the sensitivity checklists (based on Josh Lawler's Climate Sensitivity Database).
III. Work through the sensitivity checklist for one species and one place to provide an overall estimate of sensitivity as well as a list of factors that contribute to the relative sensitivity of the species and unit. Information on your species and administrative unit has been provided in the packet to help you develop a rank for sensitivity.
IV. We will take time at the end of the exercise to hear back from groups about their results.

Your assigned species will be clear from your packet's cover page. Below we have suggested species/administrative unit pairings (like fine wine and cheese), but you may opt to assess any administrative unit within your species' range if you have access to a computer and wish to look up information on your own.

1. **Species:** Foothill Yellow-legged Frog (*Rana boylii*): aquatic frog of California - BC; **Admin unit:** Umpqua-Klamath National Wildlife Refuge
2. **Species:** Greater Sage Grouse (*Centrocercus urophasianus*); **Admin unit:** Humboldt-Toiyabe National Forest
3. **Species:** Sandplain Gerardia (*Agalinis acuta*): annual plant occurring on disturbed sandy soils in Northeast USA, federally listed; **Admin unit:** Cape Cod National Seashore

Resources:

I. Species climate change sensitivity checklist
II. Place/habitat climate change sensitivity checklist
III. Species information (e.g., distribution, natural history, ecology)
IV. Place/habitat information (e.g., site description, dominant vegetation, management structure)

Species Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the species to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Generalist or specialist
Is the species more of a generalist or a specialist?

Generalist				Specialist
1	2	3	4	5

3. Disturbance regimes
How sensitive is the species likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Interspecific interactions
How sensitive are key interspecific interactions to climate change (e.g., competitive relationships, predator prey relationships, diseases, parasites)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the species rely on habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not dependent				Highly dependent
1	2	3	4	5

6. Non-climatic stressors
To what degree is the species negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Place/Habitat Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the dominant vegetation type to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Place/ecosystem size
Is the administrative unit dominated by a single ecosystem/ habitat type, or does it encompass a range of climates and ecosystems?

Broad range				Single ecosystem
1	2	3	4	5

3. Disturbance regimes
How sensitive is the administrative unit likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Individual species sensitivities
How sensitive are key species in the administrative unit to climate change (e.g., flagship species, ecosystem engineers, keystone species)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the administrative unit contain (or is it characterized by) many habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not many				Many
1	2	3	4	5

6. Non-climatic stressors
To what degree are the habitats in the administrative unit negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Greater Sage Grouse – Summary information

Natural History (Schroeder et al. 1999)

- The Sage Grouse is North America's largest grouse and is a characteristic feature of habitats dominated by big sagebrush (*Artemisia tridentata*) in western North America.
- Sagebrush habitat types have a tremendous amount of natural variation in vegetative composition, habitat fragmentation, topography, substrate, weather, and frequency of fire. Sage Grouse use a mosaic of sagebrush habitats throughout their range.
- The Sage Grouse feeds mostly on leaves, buds, stems, flowers, fruit, and insects. However, leaves dominate diet throughout year.
- This species is renowned for its spectacular breeding displays, during which large numbers of males congregate on relatively small lek sites to perform a Strutting Display and to breed with females.
- Leks often are situated on broad ridgetops, grassy swales, disturbed sites (such as burns), and dry lake beds. Lek sites tend to have less herbaceous and shrub cover than surrounding habitats.
- The Sage Grouse nests in relatively thick vegetative cover, usually dominated by big sagebrush.
- Average clutch size ranges from 6.6 to 9.1 eggs. Clutch sizes for adults tends to be 0.2–2.1 eggs greater than for yearlings. Clutches of first nests tend to be 0.2–0.9 egg greater than for renesting attempts. The proportion of females that hatch at least 1 egg varies from 15 – 70% depending on location.
- Nest success is usually cited as the most significant factors influencing the population dynamics of Sage Grouse. Nesting likelihood, renesting likelihood, juvenile survival, and adult survival are also significant factors. Nest success appears to be influenced by extrinsic factors such as weather, habitat alteration, and predators. Similar factors affect juvenile survival.
- Although no brood parasitism has been documented, abnormally large clutches (>15) may represent egg-dumping (more than female laying eggs in same nest).
- The grouse winters in areas similar to the breeding range, except that Sage Grouse winter in areas dominated by 6–43% cover of sagebrush, primarily big sagebrush, low sagebrush, and/or silver sagebrush. Variation in topography and height of sagebrush ensures the availability of sagebrush in different snow conditions.
- Can fly as fast as 78 km/h and make single flights of up to 10 km.

Disturbances (Schroeder et al. 1999)

- Primary cause of decline is habitat alteration, including adverse effects of cultivation, fragmentation, and reduction of sagebrush (*Artemisia* spp.) and other herbaceous cover. The Sage Grouse has been extirpated from British Columbia, Arizona, New Mexico, Oklahoma, Kansas, and Nebraska.
- Although Sage Grouse have adjusted to altered habitats, including alfalfa (*Medicago sativa*), wheat (*Triticum* spp.), and crested wheatgrass (*Agropyron cristatum*), the usefulness of altered habitats often depends on their configuration among native habitats.
- Broods respond to dry conditions during mid- and late summer by concentrating in areas with succulent vegetation and/or by migrating.

Known climate change responses

- Populations have been documented to decrease in response to severe droughts (Aldridge et al. 2008).
- Increased frequency of fires (due to increase in temperature and invasion of fire-adapted weeds, such a cheatgrass) may reduce Sage Grouse habitat (McKenzie et al. 2004).
- An expected increase in risk of West Nile Virus transmission may affect viability of the populations (Schrag et al. 2010).

Abstract from Aldridge et al. (2008)

Greater sage-grouse persistence and extirpation were significantly related to sagebrush habitat, cultivated cropland, human population density in 1950, prevalence of severe droughts and historical range periphery. Extirpation of sage-grouse was most likely in areas having at least four persons per square kilometer in 1950, 25% cultivated cropland in 2002 or the presence of three or more severe droughts per decade. In contrast, persistence of sage-grouse was expected when at least 30 km from historical range edge and in habitats containing at least 25% sagebrush cover within 30 km. Extirpation was most often explained (35%) by the combined effects of peripherality (within 30 km of range edge) and lack of sagebrush cover (less than 25% within 30 km). Based on patterns of prior extirpation and model predictions, we predict that 29% of remaining range may be at risk.

Spatial patterns in greater sage-grouse range contraction can be explained by widely available landscape variables that describe patterns of remaining sagebrush habitat and loss due to cultivation, climatic trends, human population growth and peripherality of populations. However, future range loss may relate less to historical mechanisms and more to recent changes in land use and habitat condition, including energy developments and invasions by non-native species such as cheatgrass (*Bromus tectorum*) and West Nile virus. In conjunction with local measures of population performance, landscape-scale predictions of future range loss may be useful for prioritizing management and protection. Our results suggest that initial conservation efforts should focus on maintaining large expanses of sagebrush habitat, enhancing quality of existing habitats, and increasing habitat connectivity.

Humboldt-Toiyabe National Forest - Summary Information

Basics

The Humboldt-Toiyabe National Forest (HTNF) is the principal U.S. National Forest located in the U.S. state of Nevada. With an area of 6,300,000 acres (2,500,000 ha), it is the largest National Forest in the lower 48 states. It does not resemble most other National Forests in that it has numerous fairly large but non-contiguous sections. Its 10 ranger districts are scattered across the many mountain ranges in Nevada, from the Santa Rosa Range in the north to the Spring Mountains near Las Vegas in the south. A small part of the forest (about 11%) is in eastern California, in the areas around Bridgeport and Markleeville and other areas east of the Sierra Nevada Mountains. The forest lies in 13 counties in Nevada and 6 in California. The counties with the largest amount of forest land are Nye, Elko, and White Pine in Nevada, and Mono County in California, but there are 15 other counties with land in this widely dispersed forest. Forest headquarters are located in Sparks, Nevada.

The Humboldt-Toiyabe National Forest encompasses a broad array of wildlife habitats ranging in elevation from approximately 4,100 feet to 12,374 feet. The forest exhibits a great variation in climate, ranging from arid and desert-like in some areas to subalpine in others, and can have temperature fluctuations ranging from well below zero in the winter to up to 120 degrees Fahrenheit during the summer.

The habitat-types found in the HTNF are: Alpine (above 10,000 feet, lying just below the snow line), Aspen woodlands (mainly composed by *Populus spp*., commonly found between 5,200 and 10,500 feet), Bristlecone Pines (*Pinus lonageva*, usually found in an exposed, windswept, harsh environment, free of competition from other plants and the ravages of insects and disease between 10,000 and 11,000 feet), Whitebark Pine (*Pinus albicaulis*) and Limber Pine (*Pinus flexilis*)Pine (commonly found on rocky slopes and ridges of high mountains. They can grow on high forest sites that are too rugged, dry, and windy for most other trees), Mountain Brush (including Mountain Big Sage Brush, serviceberry, chokecherry, bitter cherry, antelope bitterbrush, cliffrose, mountain mahogany, ninebark, and Gambel oak; it occurs on gentle slopes and south-facing slopes, between 5,000 and 9,000 feet), Pinyon-Juniper (it generally occurs on gently rolling hills to steep mountain slopes, rocky canyons, and narrow ridges between 4,500 and 9000 feet, with pinyon pine occurring more at the higher elevations and juniper occurring more at the lower elevations), Ponderosa Pine (it is one of the most widely distributed pines in western North America, although it is less common on the HTNF. It can generally be found at elevations up to around 9,000 feet and in many different habitat types), Riparian areas (Riparian areas are most commonly found near springs, creeks, rivers, and lakes that contain water, and can be narrow strips of grass and willows, or broad grassy areas), and Sagebrush (which can be found from below 3,000 feet to above 10,000 feet elevation in a variety of climate zones from low foothills to subalpine areas).

The HTNF has been a center of human activity since the early days. Overall, there are between 80,000 – 100,000 prehistoric and historic archaeological sites. The various types of heritage resources range from the enigmatic squiggles and curlicues of prehistoric rock art, to the phenomenal mining towns of the 19th century, to Euro-American emigrant trails and roads. A number of Native American tribes claim Humboldt-Toiyabe lands as part of their ancestral homelands. These include different groups of Southern Paiute, Northern Paiute, Western Shoshone, and Washoe Indians.

Currently, the HTNF hosts a number of different activities, from timber production, mining, livestock, conservation, hunting, and recreation (from hiking to gold panning) among others.

Species
The wide variety of habitats found in HTNF holds a large number of plant species and communities. Among them are: Aspen (*Populus sp.*), Bristlecone Pine (*Pinus longaeva*, which is the longest-lived organism known, reaching up to 5,000 years, and grows in isolated groves). Whitebark Pine (*Pinus albicaulis*) and Limber Pine (*Pinus flexilis*), Big Sagebrush (*Artemisia tridentata*), Single-leaf Pinyon (*Pinus monophylla*), Junipers (*Juniper spp.*), Ponderosa Pine (*Pinus ponderosa*), Lake Tahoe Draba (*Tahoe draba*), Washoe Pine (*Pinus washoe*), Jeffrey Pine (*Pinus jefferyi*), among others.

Many animal species inhabit the HTNF, including mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), desert cottontail (*Sylvilagus audubonii*), pinyon jays (*Gymnorhinus cyanocephalus*), Clark's nutcrackers (*Nucifraga columbiana*), Greater sage grouse, chukar (*Alectoris chukar*), pronghorn (*Antilocapra americana*), wild horses and burros, desert bighorn sheep (*Ovis canadensis nelson*), bald eagle (*Haliaeetus leucocephalus*), a few mountain lions (*Puma concolor*) in more remote areas of some of the mountain ranges, black bear (*Ursus americanus*), bobcat (*Lynx rufus*)and pine marten (*Martes americana)*.

Among the amphibians found in the HTNF, are the:

Mountain Yellow-legged frog (*Rana muscosa*), Although it was once the most abundant high-elevation frog in the Sierra Nevadas, many populations in the northern Sierra Nevada and elsewhere have since become extinct and the species has disappeared from 70-90% of its historic range. It is federally listed as a Candidate Species.

Yosemite Toad (*Bufo canorus*), As of the mid-1990’s, it had declined substantially or disappeared from over 50% of the sites where it was known historically. It is federally listed as Candidate Species.

Columbia Spotted frog (*Rana luteiventris*). Great Basin Population. A significant number of the remaining populations occur on the Humboldt-Toiyabe National Forest. It is federally listed as Candidate Species.

The endangered Paiute cutthroat trout lives nowhere else in the world except on the Carson Ranger District in the HTNF.

Key issues
Disturbances: Aspen stands are preferred livestock grazing areas. Both domestic sheep and cattle use these areas for watering and bedding. This use, if not managed properly, can damage saplings and decrease aspen reproduction. Aspen stands are preferred spots for camping and recreational activities. These activities can cause soil compaction from vehical and foot traffic, and tree wounding from tent ropes, clotheslines, nails, carving, and any activity that wounds the living bark of the tree.

Invasive species: Cheatgrass (*Bromus tectorum*), also known as downy brome, is an annual plant native to Eurasia. This aggressive, invasive weed was originally introduced into North America through soils brought by ocean-going vessels and is now a dominant species in the Intermountain West. Cheatgrass is notorious for its ability to thrive in disturbed areas, but it also will invade undisturbed areas. As this invasive weed begins to dominate an area, it alters native plant communities and displaces native plants thus impacting wildlife. Additional negative impacts include changes in soil properties, a decline in agricultural production, and altered fire frequencies. Cheatgrass is highly flammable and densely growing populations provide ample, fine-textured fuels that increase fire intensity and often decrease the intervals between fires. If fire should strike cheatgrass-infested land, native plant communities can be inextricably altered. Both the Mountain Yellow-legged frog and Yosemite Toad are declining primarily due to competition with non-native fishes.

Disease: White pine blister rust (*Cronartium ribicola*) is an exotic pathogen in Europe and North America. It occurs in whitebark pine and has recently been found in whitebark pine on the Humboldt-Toiyabe. Whitebark pine has very little natural resistance to this introduced disease and concern exists throughout the western United States about the fate of this high elevation species. Efforts are underway among universities, the Forest Service, and other public and private agencies to identify individual trees which might exhibit resistance to this disease and collect the seeds for future restoration efforts.

Climate change: In the last 100 years, the region warmed by 0.5 to 1.5°C (1 to 3°F) and is projected to warm another 3.6 to 9°F (2 to 5°C) by the end of the century. Since about 1980, western U.S. winter temperatures have been consistently higher than long-term values and average winter snow packs have declined. Periods of higher than average precipitation have helped to offset the declining snow packs. Winter temperatures are increasing more rapidly than summer temperatures, particularly in the northern hemisphere, and there has been an increase in the length of the frost-free period in mid- and high-latitude regions of both hemispheres. Winter temperatures are increasing more rapidly than summer temperatures, particularly in the northern hemisphere, and there has been an increase in the length of the frost-free period in mid- and high-latitude regions of both hemispheres. Annual precipitation (in the Northwestern and Intermountain regions) increased by 10% on average, and by as much as 30–40% in some areas. Annual precipitation (in the Northwestern and Intermountain regions) increased by 10% on average, and by as much as 30–40% in some areas (USDA Forest Service 2011)

Community shifts: Since the 1860s, many bunchgrass and sagebrush–bunchgrass communities, which dominated the Intermountain West, have shifted to pinyon and juniper woodland or introduced annual-dominated communities. Concerns related to these changes in community composition include increased soil erosion changes in soil fertility, losses in forage production, changes in wildlife habitat, and alteration of pre-settlement plant communities

References

Aldridge, C. L., S. E. Nielsen, H. L. Beyer, M. S. Boyce, J. W. Connelly, S. T. Knick, and M. A. Schroeder. 2008. Range-wide patterns of greater sage-grouse persistence. Diversity and Distributions **14**:983-994.

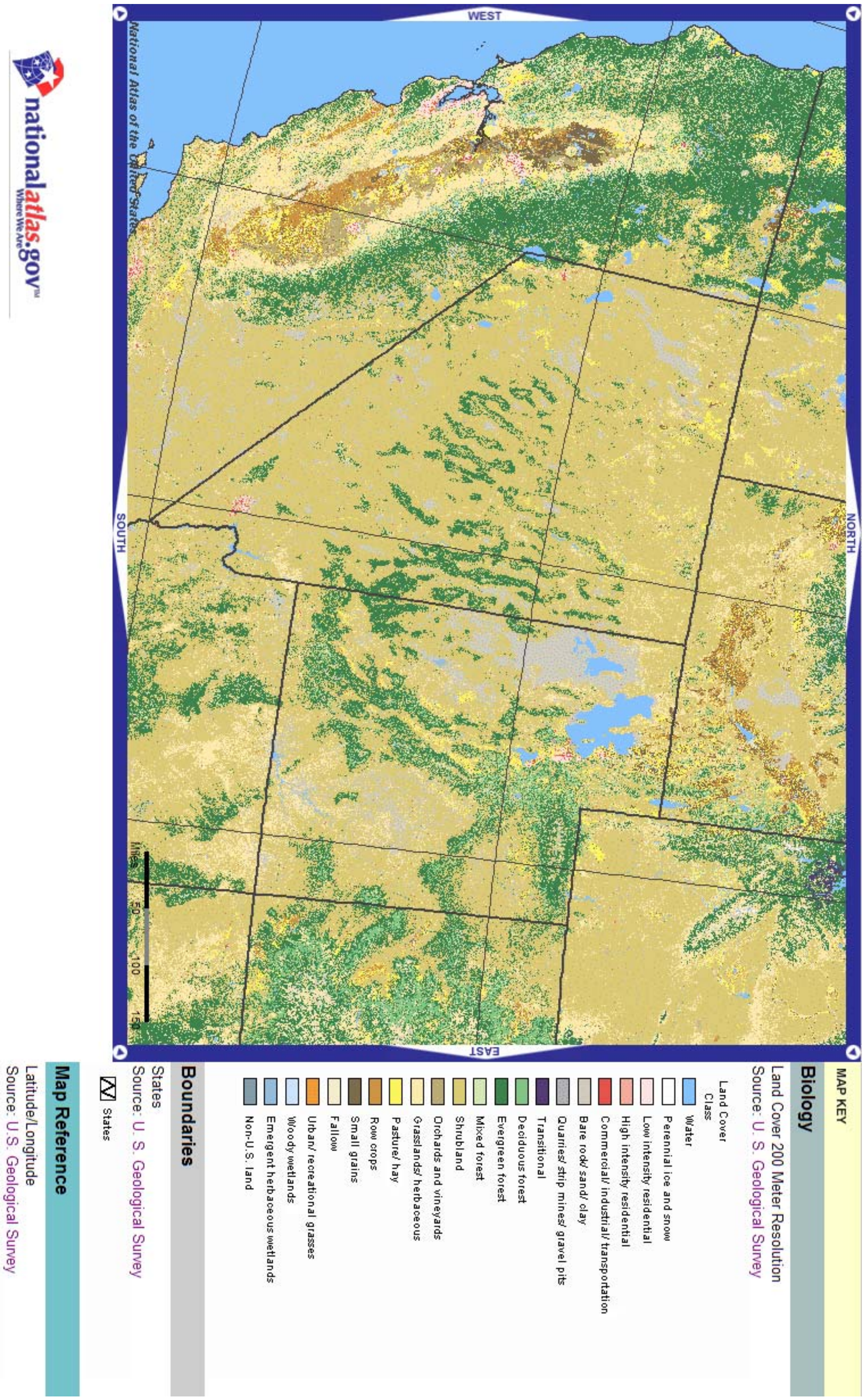
McKenzie, D., Z. Gedalof, D. L. Peterson, and P. Mote. 2004. Climatic Change, Wildfire, and Conservation. Conservation Biology **18**:890-902.

Schrag, A., S. Konrad, S. Miller, B. Walker, and S. Forrest. 2010. Climate-change impacts on sagebrush habitat and West Nile virus transmission risk and conservation implications for greater sage-grouse. GeoJournal **76**:561-575.

Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Greater Sage-Grouse (Centrocercus urophasianus). The Birds of North America Online. Retrieved December 26, 2011, from http://bna.birds.cornell.edu.offcampus.lib.washington.edu/bna/species/425/articles/introduction.

USDA Forest Service. 2011. Humboldt-Toiyabe Natinal Forest Climate Change Vulnerability Report. Page 17.

Humboldt-Toiyabe National Forest land cover



Exercise 2.2: Assessing exposure

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

Output: A discussion of exposure for your species and your administrative unit The goal of the questions below is to get you thinking about what elements of exposure are most important for assessing the vulnerability of the particular species, habitats, or places with which you are concerned. The metrics of change most commonly presented in the media—e.g. changes in average global or regional temperature and changes in average global or regional rainfall—aren't always the most appropriate metrics for a particular VA.

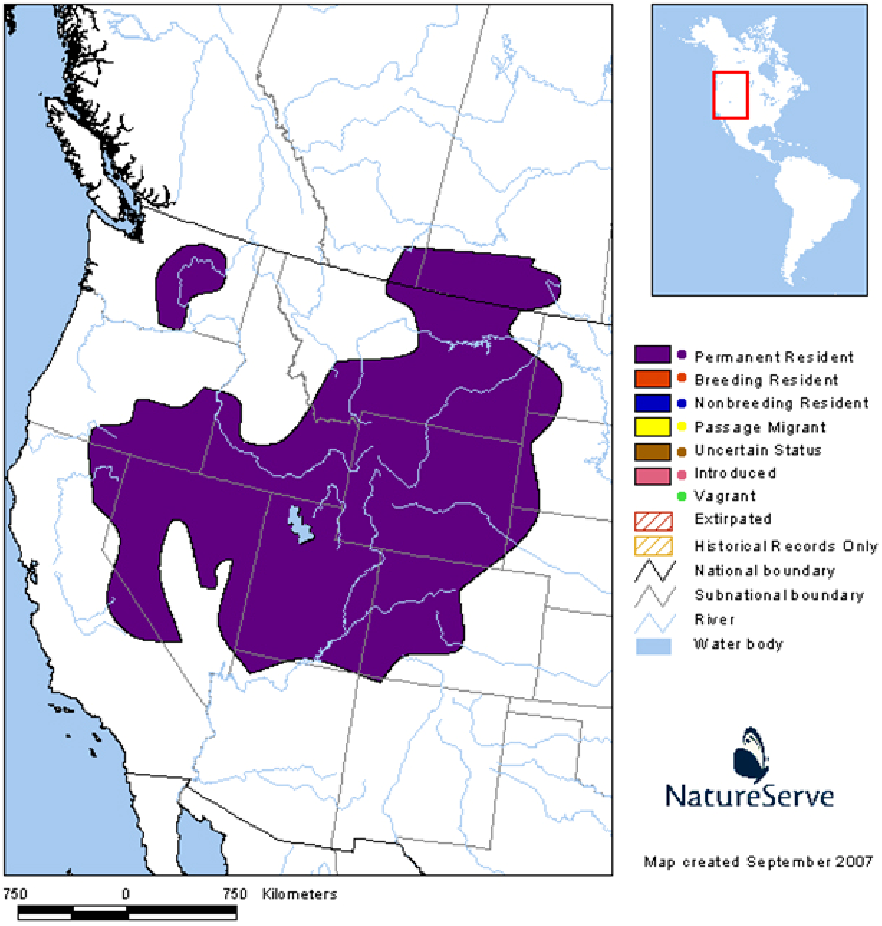
Resources:

I. Range (for species) or boundaries (for habitat/administrative unit)
II. Shaded relief map for relevant area (created using the National Atlas; can go to nationalatlas.gov and look in the geology layer if you want to zoom in)
III. Maps of projected changes in various climate variables for the relevant area.

Questions to consider:

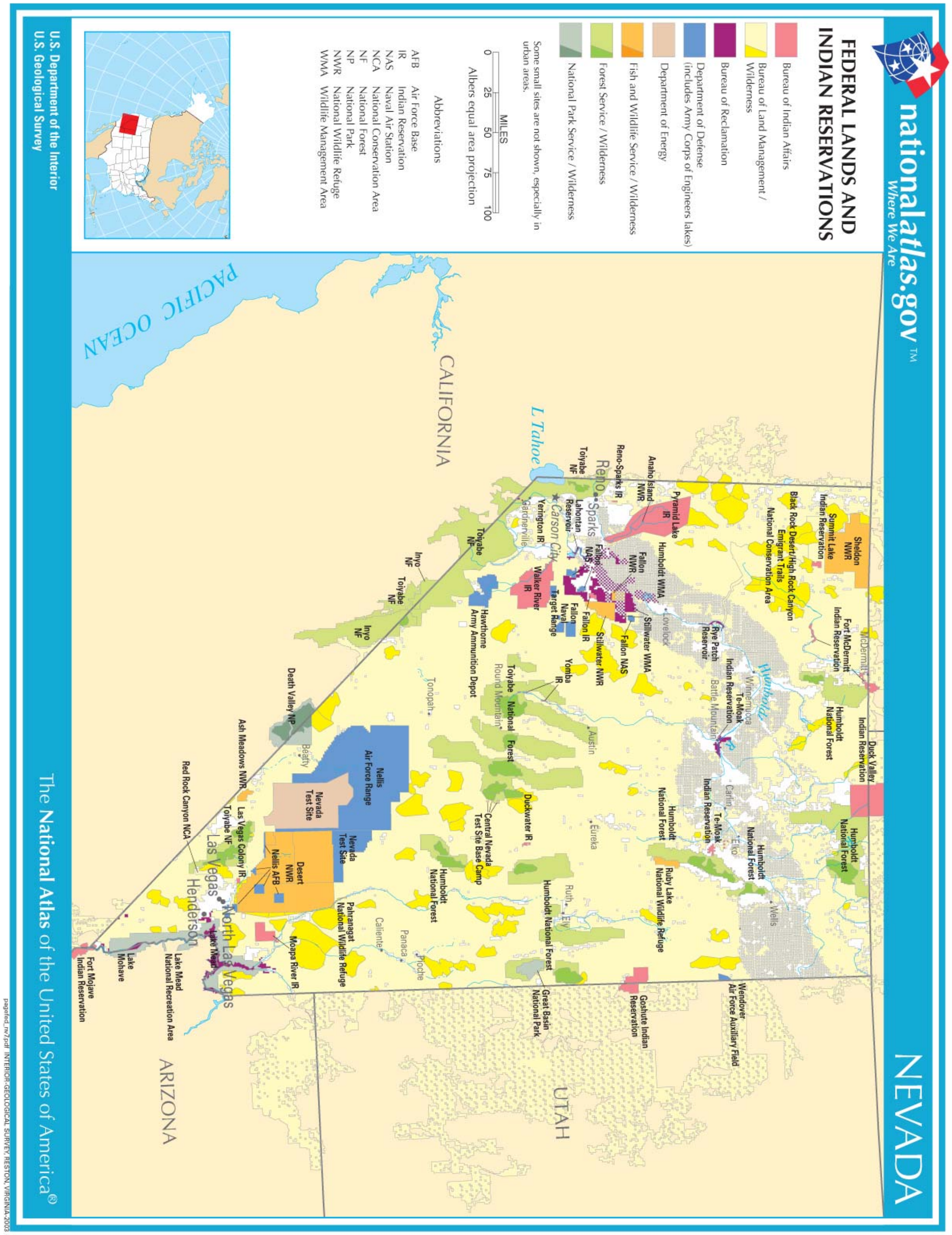
1. What elements of exposure are likely to be most relevant or important for the species in question? For the habitat or administrative unit? (NOTE: there may be elements that are in the "most relevant" category that have not been provided to you in the packet. List any layers missing that you think would help you better evaluate exposure).
2. For species: What factors are most important in determining the species' range? Think not just about climate variables, but about other factors as well (e.g. presence of particular plants, absence of particular competitors, etc.). How might this influence the variables on which you chose to focus?
3. For administrative units: What are the goals, vision, or mandate for this administrative unit? What factors are most important in determining the ability of the unit to meet these goals, vision, and mandates?
4. What factors might influence exposure? That is, what factors influence the actual amount of climatic change experienced by the species or place in question? For example, some types of air pollution reflect heat and thereby slow warming; type and density of plant cover can influence heating, cooling, moisture, and fire regime.
5. How would you express exposure for the species in question—maps of each variable separately? Of only the most important variables? A combined map showing average change in all variables? A single ranking or score for exposure across the entire range/unit? Exposure maps or scores for a few key species or habitat types within the administrative unit? Think about various ways you might want to use the VA results and how different ways of expressing exposure (and ultimately overall vulnerability) might be better or worse for each type of use.

Greater Sage Grouse Range Map



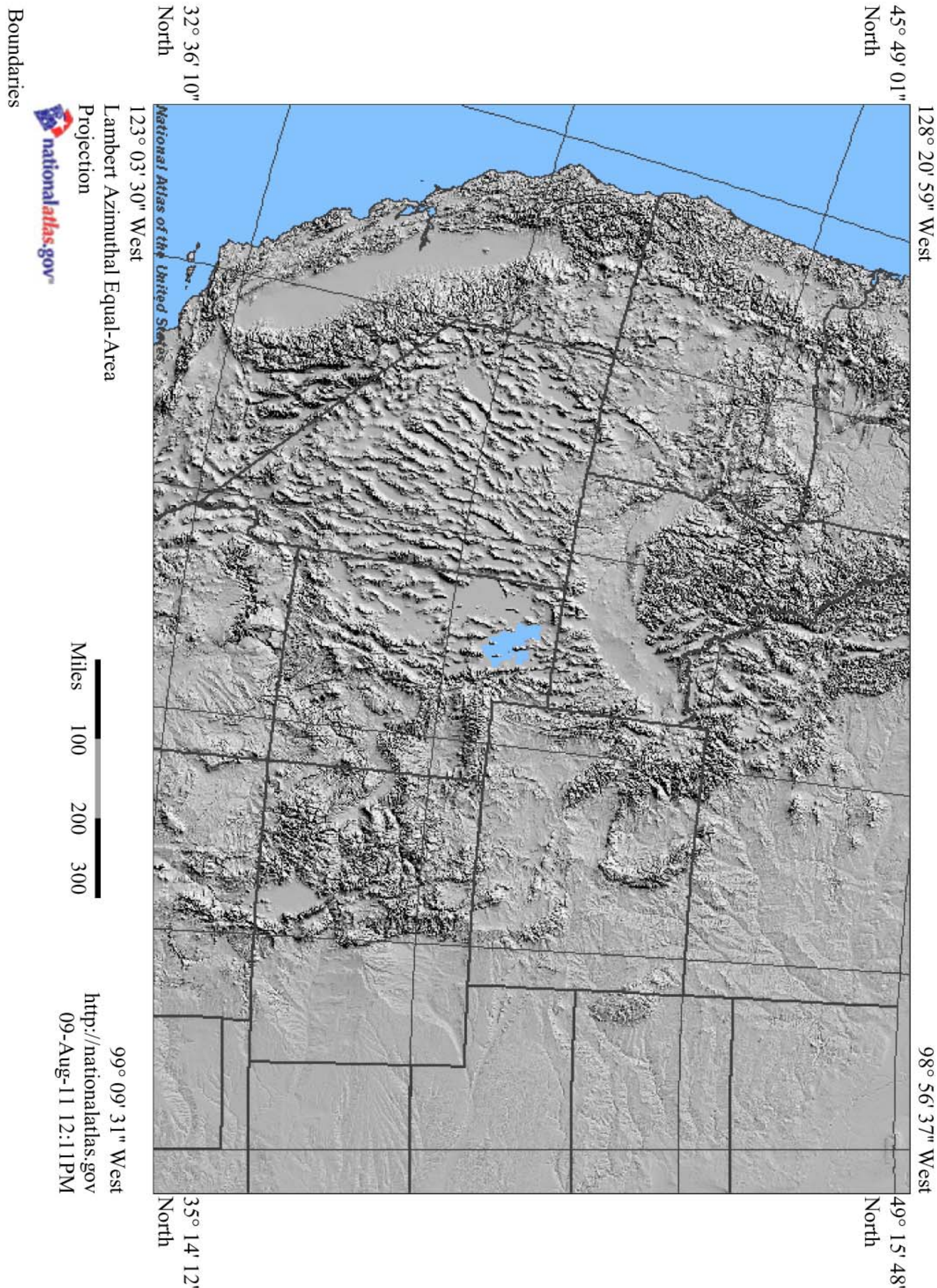
Range includes southeast quarter of Oregon, northeast and east border of California, southern half of Idaho, northern two-thirds of Nevada, portions of ne., n. and s. Utah, portions of western half of Colorado, most of Wyoming (but absent from northwest and southeast corners), eastern two-thirds and southwest corner of Montana, extreme southwest corner of N. Dakota, extreme northwest and southwest corners of S. Dakota, extreme southeast corner of Alberta, western portion of extreme s. Saskatchewan, and small portions of central Washington (Schroeder et al. 1999)

Humboldt-Toiyabe National Forest boundary

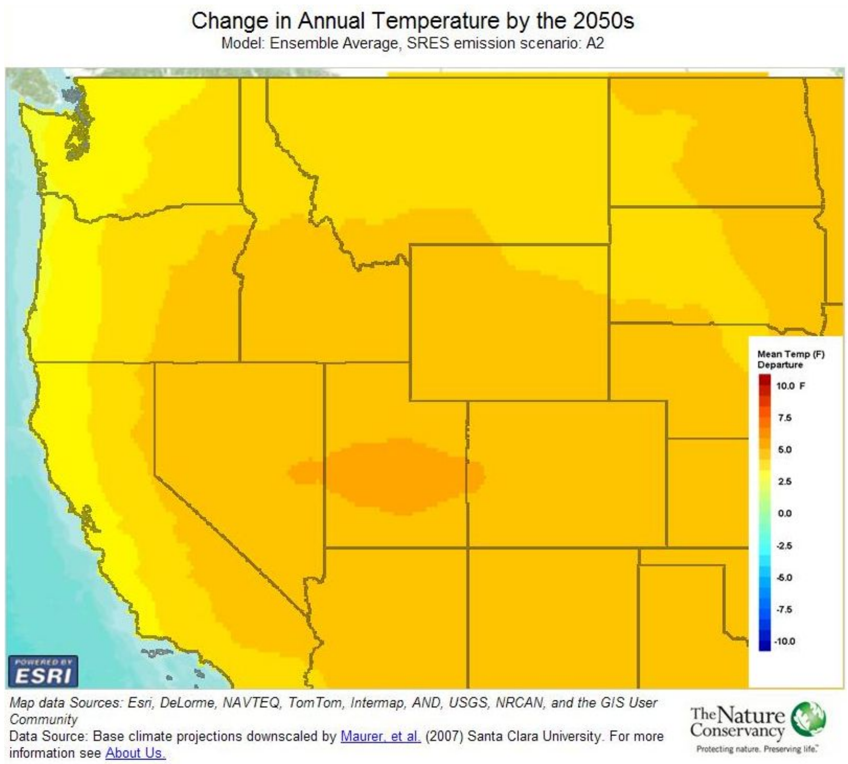


Greater Sage Grouse exposure assessment tools

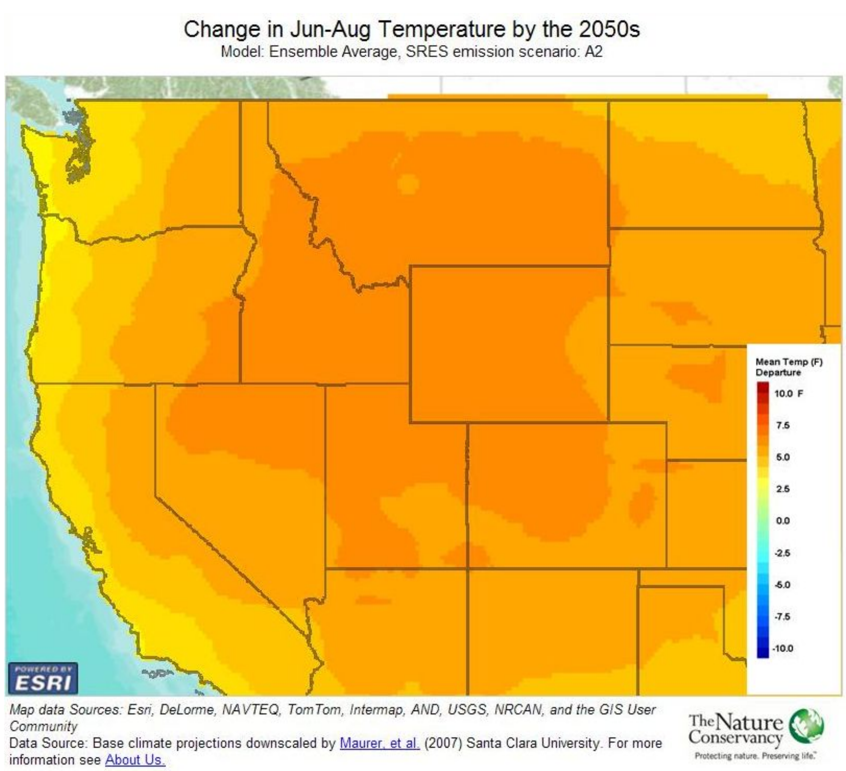
Topography



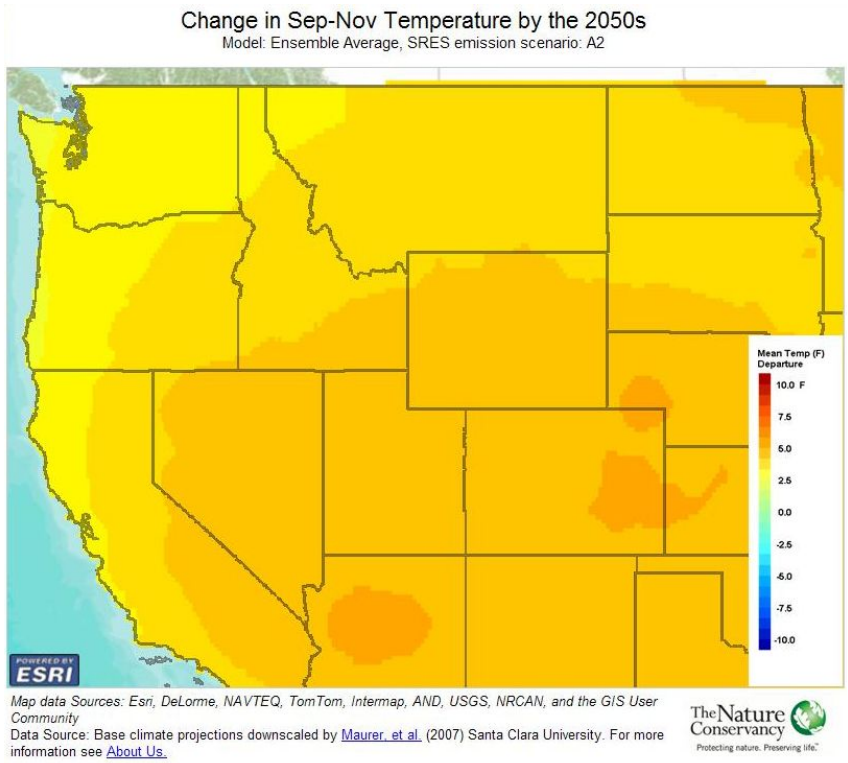
Annual temperatures



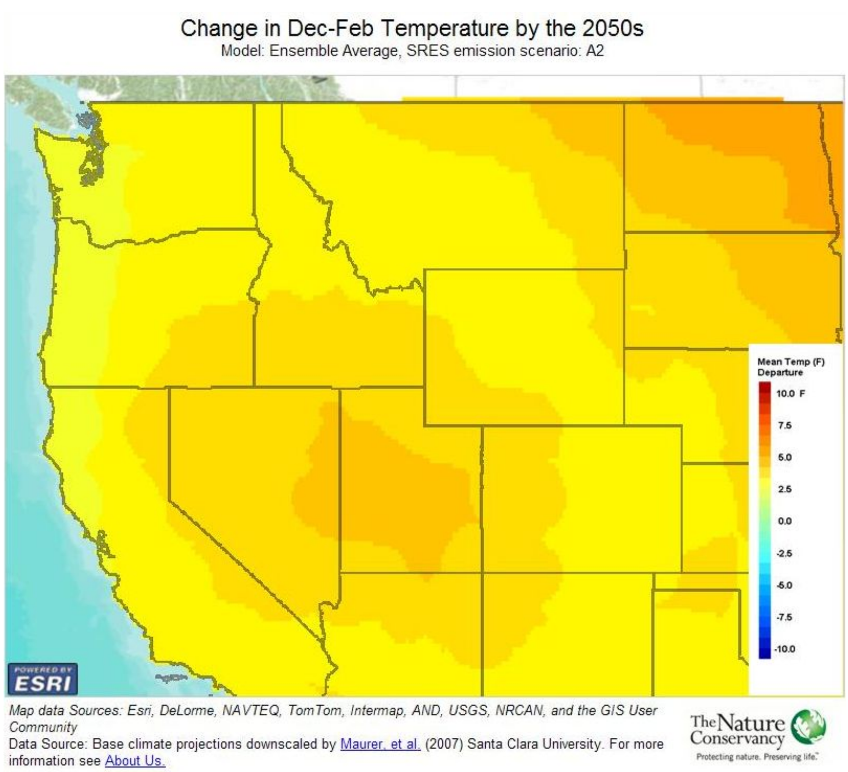
Summer temperatures



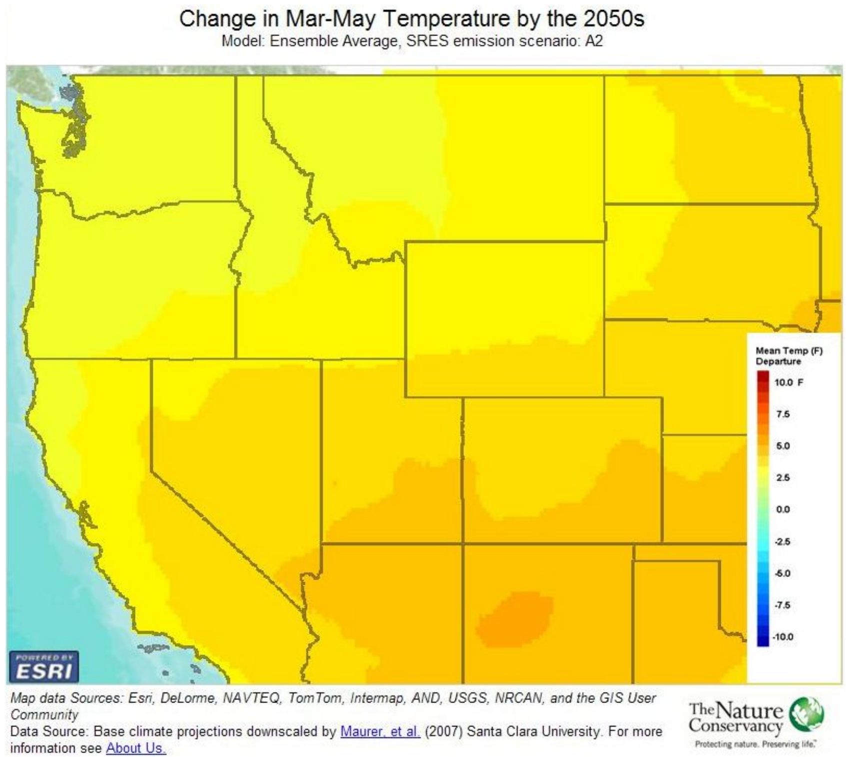
Fall temperatures



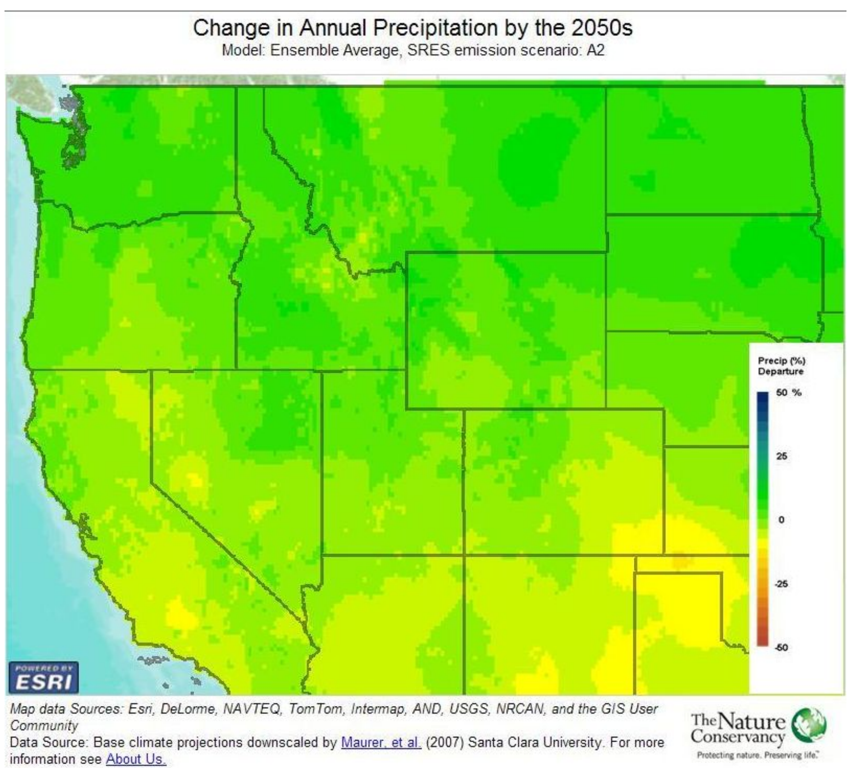
Winter temperatures



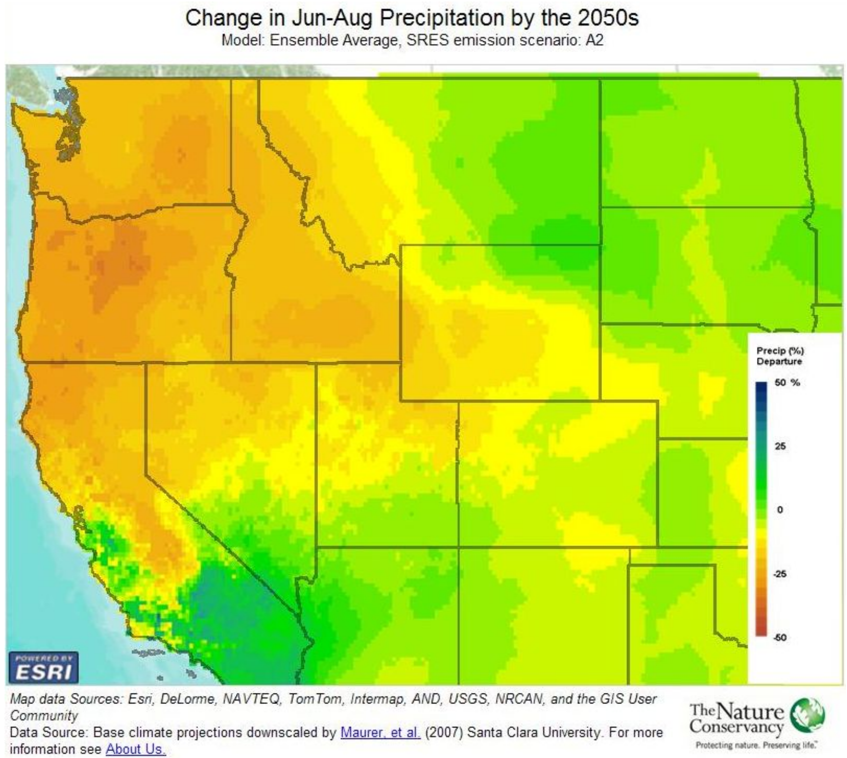
Spring temperatures



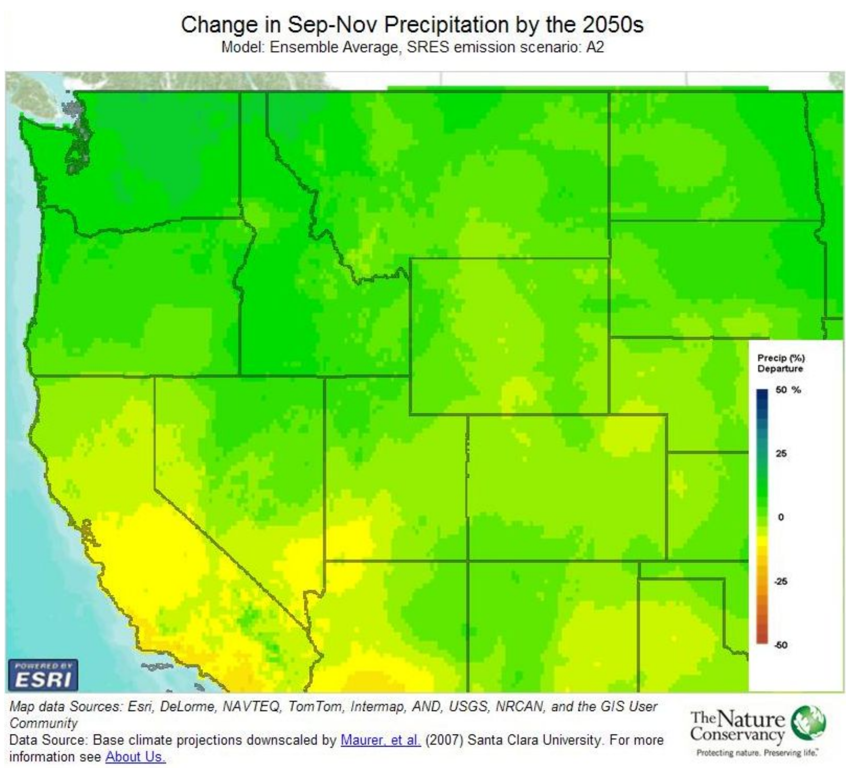
Annual precipitation



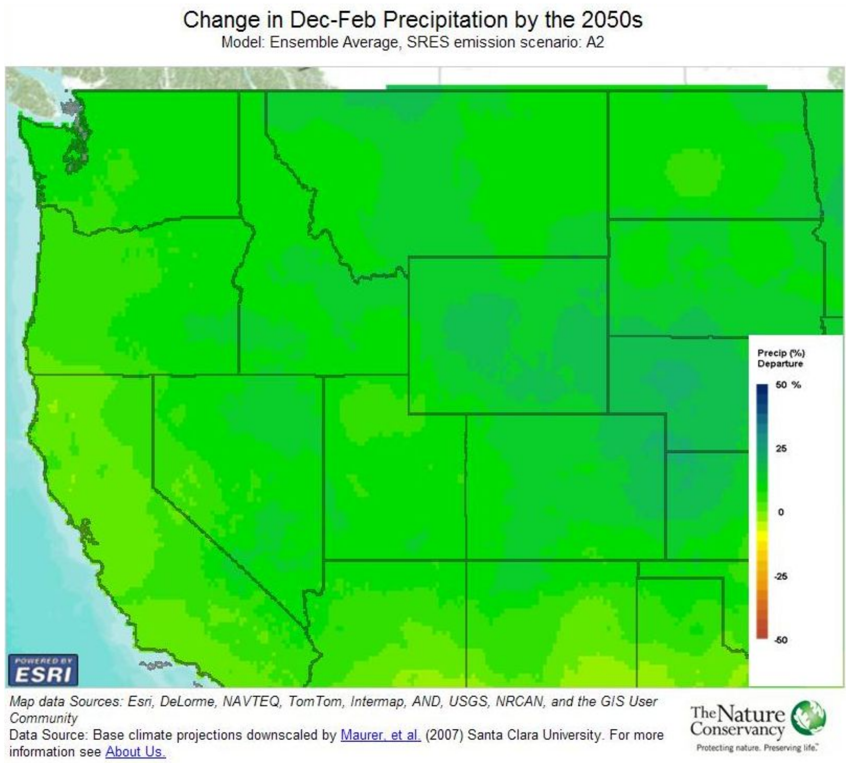
Summer precipitation



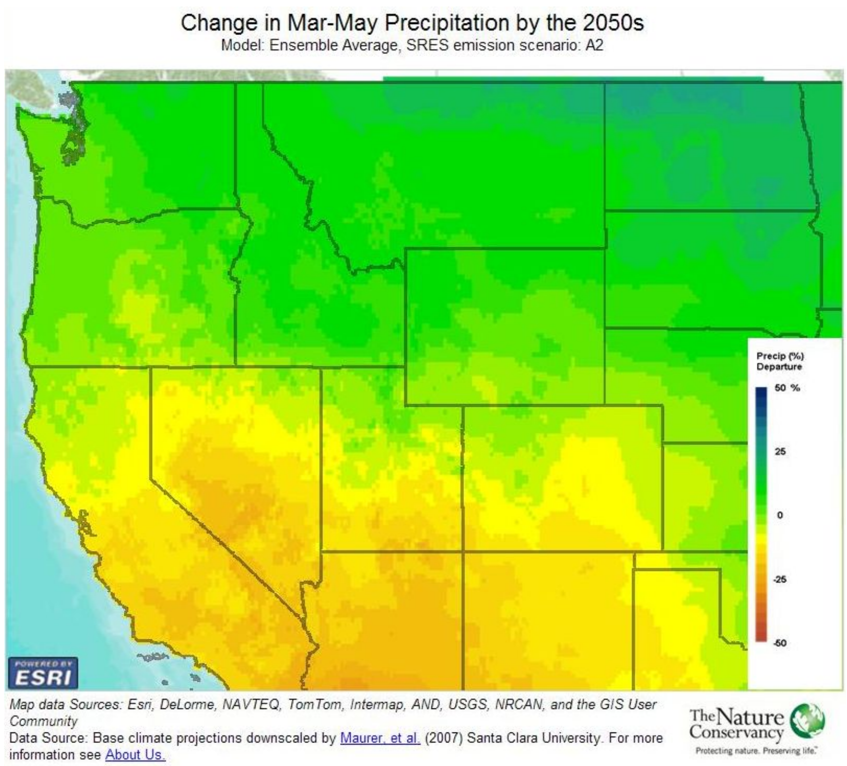
Fall precipitation

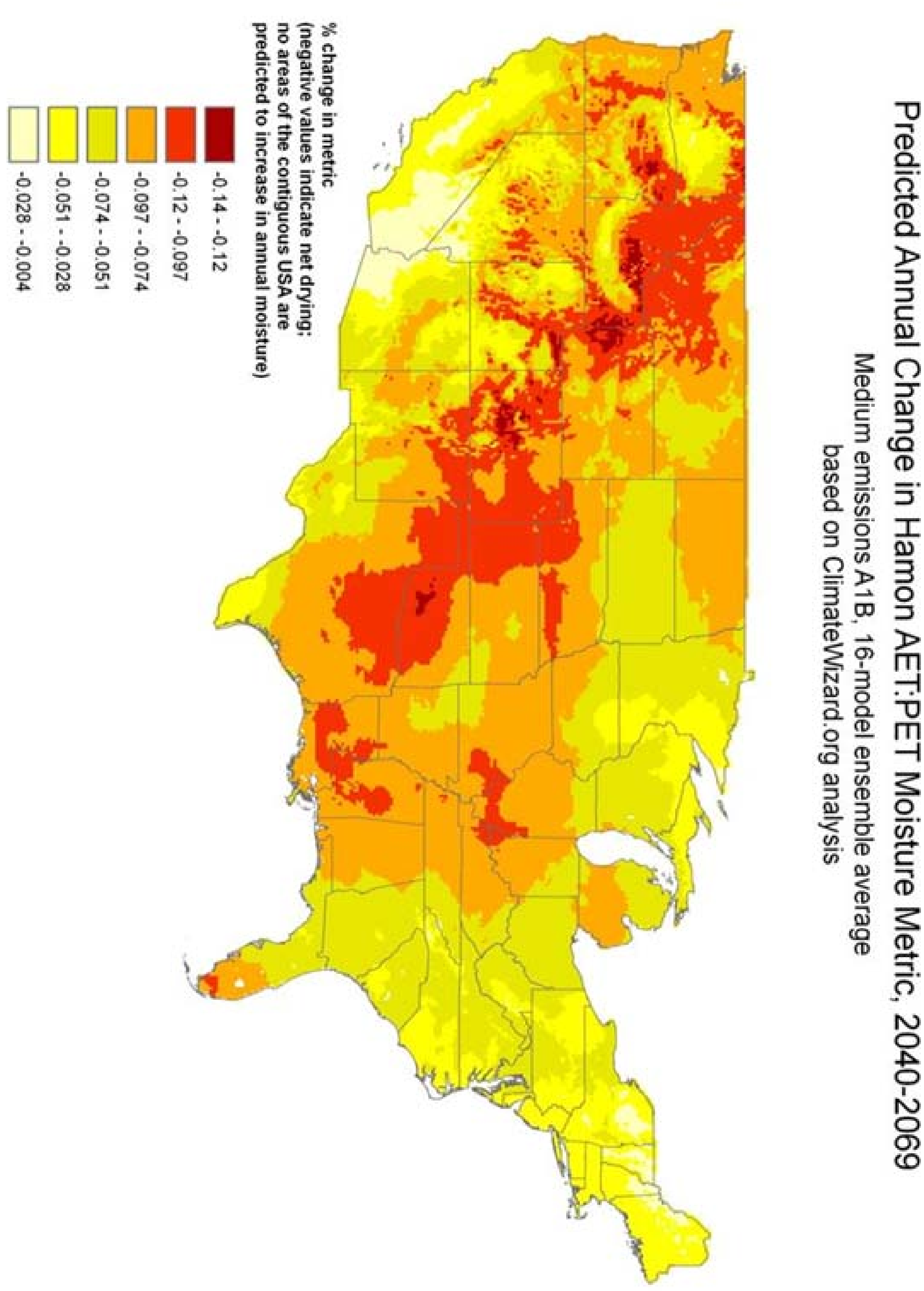


Winter precipitation



Spring precipitation




Predicted Annual Change in Hamon AET:PET Moisture Metric, 2040-2069
Medium emissions A1B, 16-model ensemble average
based on ClimateWizard.org analysis
% change in metric
(negative values indicate net drying;
no areas of the contiguous USA are
predicted to increase in annual moisture)
-0.14 - -0.12
-0.12 - -0.097
-0.097 - -0.074
-0.074 - -0.051
-0.051 - -0.028
-0.028 - -0.004

Exercise 2.3: Adaptive Capacity and Assessing Vulnerability

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

In this exercise, we're asking you to think about the ability of species and habitat/administrative units to respond to climate change in ways that minimize its negative effects. Remember, don't get too caught up in whether you'd categorize a particular characteristic as adaptive capacity vs. exposure or sensitivity; the key is to think about vulnerability from a number of angles.

Output:

1. A measure of adaptive capacity for your species and your administrative unit
2. An overall vulnerability score/ranking for your species and administrative unit. Do this by pooling the results of your sensitivity, exposure, and adaptive capacity analyses in a way that makes sense to you. This could be qualitative or quantitative, spatial or numeric, it's up to you. Just be ready to defend your choices!

Resources:

I. Species/place information from the Sensitivity Exercise
II. Highways map
III. Pollution sources map (Air Releases, Superfund National Priorities List Sites, Toxics Release Inventory, Water Discharge Permits; (created using the National Atlas; can go to nationalatlas.gov and look at the "environment" layer if you want to zoom in)
IV. GAP protected areas map

Questions to consider:

Species:

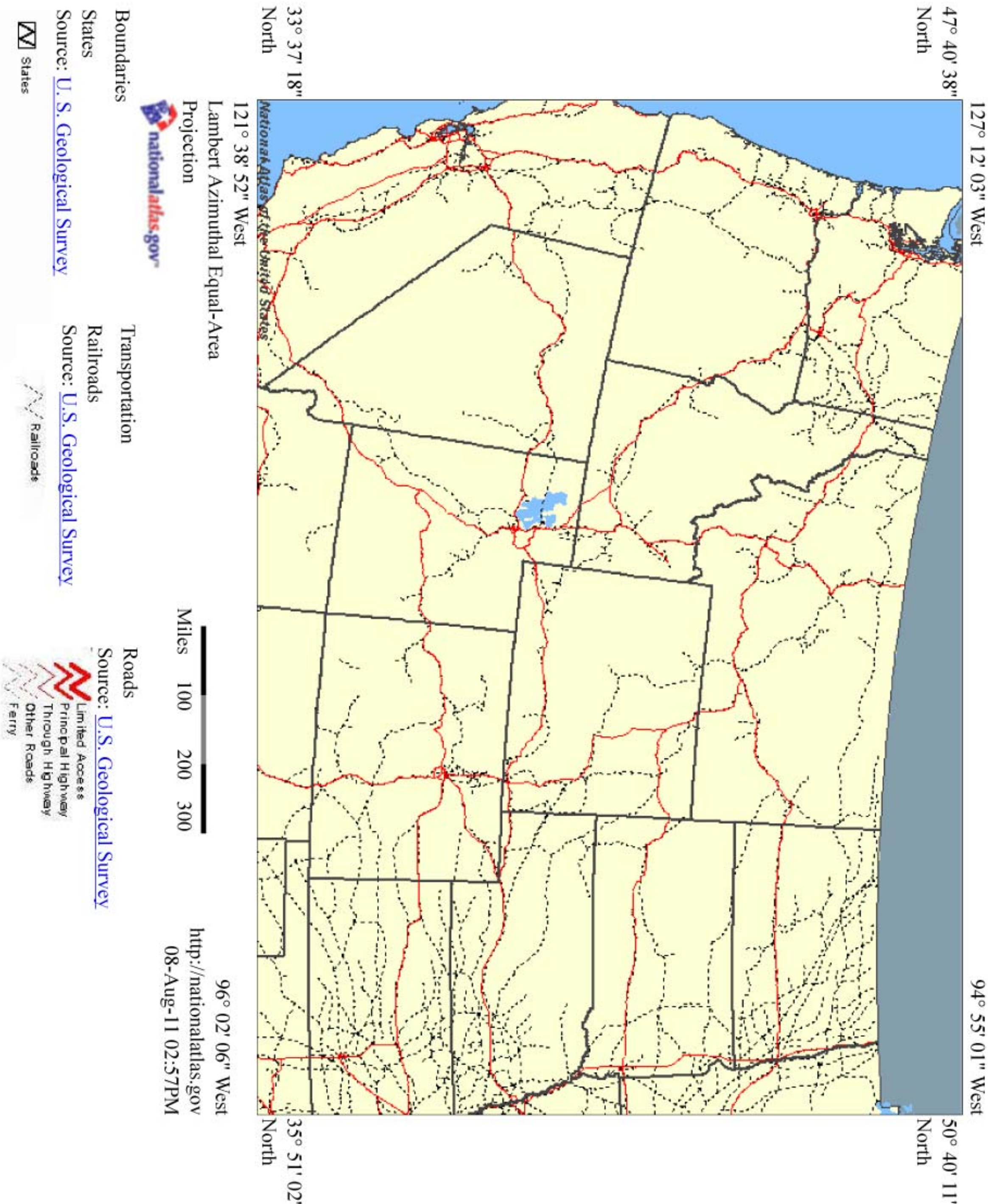
- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes in their environment?
- Is there evidence that this species is already adjusting/adapting to change (e.g. shifting behavior, range, host plants, etc.)?
- Is the geography, land use, etc. such that it would be possible for individuals to seek out refugia during times of particular climate stress (e.g. prolonged heat wave)?
- Is the geography, land use, etc. such that it would be possible for species range shift to occur? Remember that species' range shifts typically happen by differential survival and reproduction, not by the purposeful movement of individuals to new locations.
- Are there multiple populations with enough connectivity among them to allow for rescue effects and gene flow?

Administrative unit/habitat:

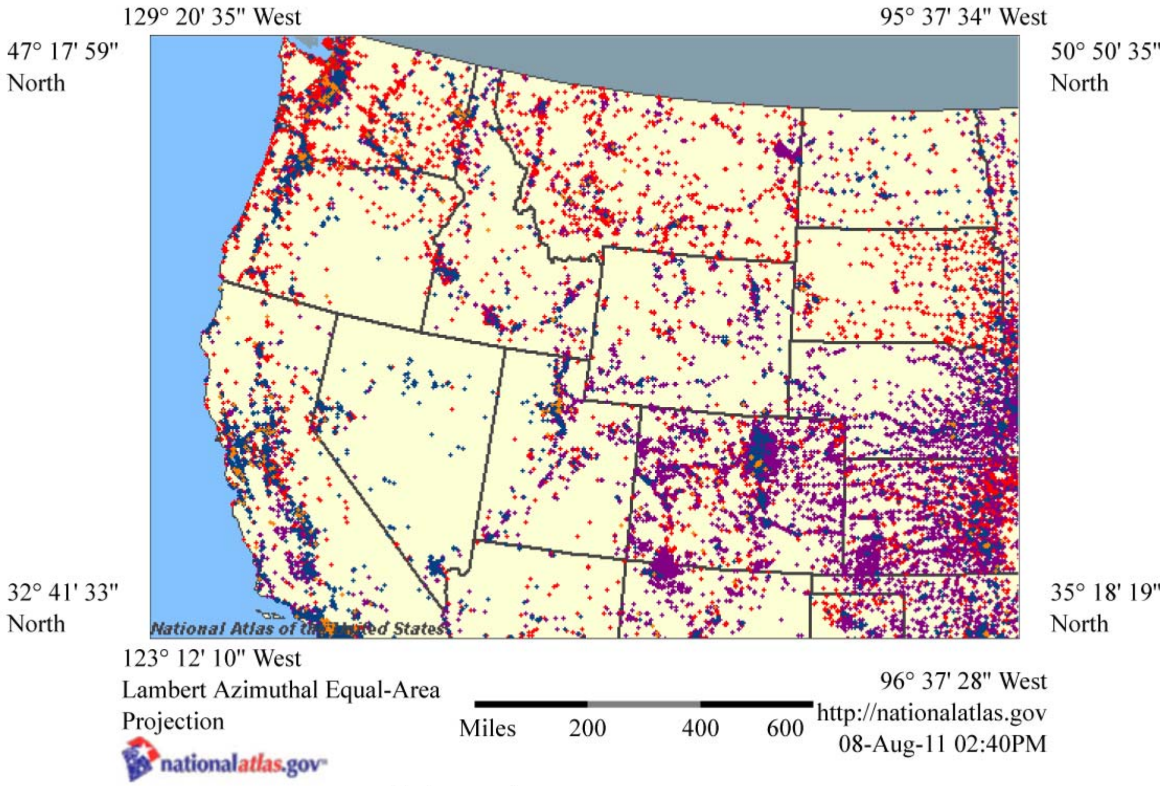
- What are the defining characteristics of the habitat community, and how vulnerable are they to climate change? E.g. presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is there a diversity of species in each functional group within the community/habitat?
- Is the geography, land use, etc. such that it would be possible for the community/habitat to shift location over time?
- Are there microclimates within the area that could support refugial communities?
- What is the nature of people's relationship to this habitat/community? Does it occur in areas where there is strong development pressure? Do people value this habitat because of services it provides (e.g. clean water, hunting or fishing opportunities, etc.)?
- Consider adaptive capacity of species and habitats within the unit.
- How rigid/specific are the rules governing management of the unit (e.g. for National Parks, what is in the enabling legislation)?
- Is there a General Management Plan or something similar? If so, how does this affect the adaptive capacity of the unit?

Greater Sage Grouse Adaptive Capacity Assessment Tools

Roads



Environmental Risk Sites



Boundaries

States
Source: U. S. Geological Survey

States

Environment

Water Discharge Permits
Source: U.S. Environmental Protection Agency

Water Discharge Permits

Air Releases
Source: U.S. Environmental Protection Agency

Air Releases

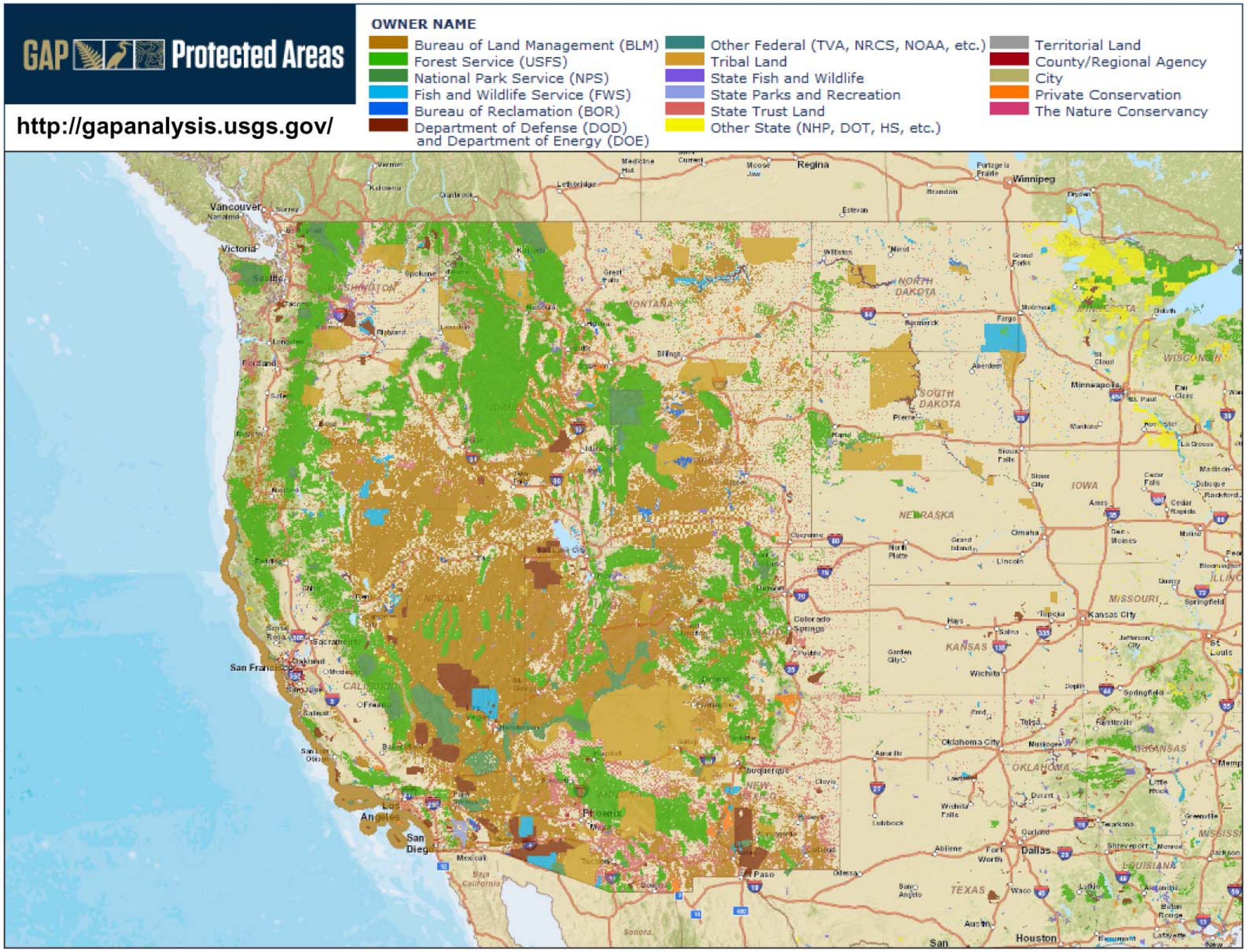
Toxics Release Inventory
Source: U.S. Environmental Protection Agency

Toxics Release Inventory

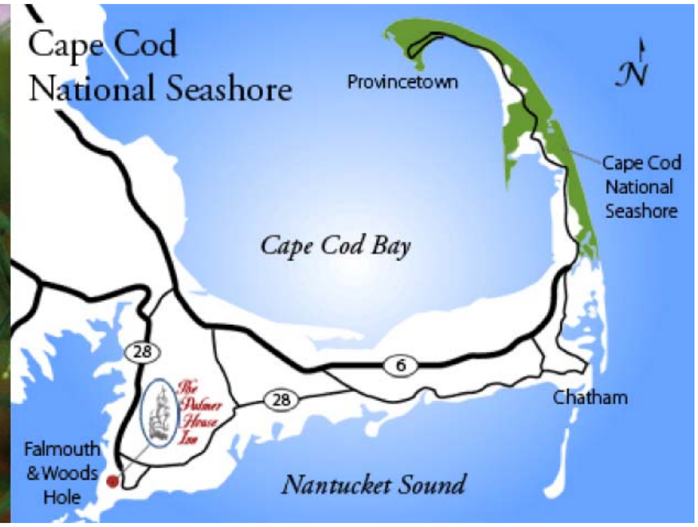
Superfund National Priorities List Sites
Source: U.S. Environmental Protection Agency

Superfund National Priorities List Sites

Protected Areas in Greater Sage Grouse range



Sandplain Gerardia (*Agalinis acuta*) and Cape Cod National Seashore



Contents

Foothill Yellow-legged Frog (*Rana boylii*) and Umpqua National Forest / Klamath National Wildlife Refuge

Contents

Exercise 2.1: Assessing sensitivity

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group
Output: Sensitivity checklist

We want you to gain experience identifying and articulating components of sensitivity for species, habitats, and ecosystems. You may find yourself distracted by the question of whether a particular characteristic is a component of sensitivity, exposure, or adaptive capacity; in the end it doesn't matter which bin you put characteristics into. What matters is that you understand how particular characteristics contribute to vulnerability or lack thereof.

Steps:

I. You will be working in groups of 6-8 people around a table. Each table will have a packet of information for Exercises 2.1, 2.2, and 2.3. This packet will include a variety of maps related to a particular species and administrative unit.
II. Examine the sensitivity checklists (species and administrative unit; based on Josh Lawler's Climate Sensitivity Database).
III. Work through the sensitivity checklist for one species and one place to provide an overall estimate of sensitivity as well as a list of factors that contribute to the relative sensitivity of the species and unit. Information on your species and administrative unit has been provided in the packet to help you develop a rank for sensitivity.
IV. We will take time at the end of the exercise to hear back from groups about their results.

Your assigned species will be clear from your packet's cover page. Below we have suggested species/administrative unit pairings (like fine wine and cheese), but you may opt to assess any administrative unit within your species' range if you have access to a computer and wish to look up information on your own.

1. **Species:** Foothill Yellow-legged Frog (*Rana boylii*): aquatic frog of California - BC; **Admin unit:** Umpqua-Klamath National Wildlife Refuge
2. **Species:** Greater Sage Grouse (*Centrocercus urophasianus*); **Admin unit:** Humboldt-Toiyabe National Forest
3. **Species:** Sandplain Gerardia (*Agalinis acuta*): annual plant occurring on disturbed sandy soils in Northeast USA, federally listed; **Admin unit:** Cape Cod National Seashore

Resources:

I. Species climate change sensitivity checklist
II. Place/habitat climate change sensitivity checklist
III. Species information (e.g., distribution, natural history, ecology)
IV. Place/habitat information (e.g., site description, dominant vegetation, management structure)

Species Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the species to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive — Moderately sensitive — Very sensitive
1 2 3 4 5

2. Generalist or specialist
Is the species more of a generalist or a specialist?

Generalist — Specialist
1 2 3 4 5

3. Disturbance regimes
How sensitive is the species likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive — Moderately sensitive — Very sensitive
1 2 3 4 5

4. Interspecific interactions
How sensitive are key interspecific interactions to climate change (e.g., competitive relationships, predator prey relationships, diseases, parasites)

Not very sensitive — Moderately sensitive — Very sensitive
1 2 3 4 5

5. Sensitive habitats
Does the species rely on habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not dependent — Highly dependent
1 2 3 4 5

6. Non-climatic stressors
To what degree is the species negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted — Severely impacted
1 2 3 4 5

Place/Habitat Climate Change Sensitivity Checklist

1. Physiological sensitivity
How sensitive is the physiology of the dominant vegetation type to changes in moisture, temperature, CO_2 concentrations, pH?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

2. Place/ecosystem size
Is the administrative unit dominated by a single ecosystem/ habitat type, or does it encompass a range of climates and ecosystems?

Broad range				Single ecosystem
1	2	3	4	5

3. Disturbance regimes
How sensitive is the administrative unit likely to be to a change in a disturbance regime (e.g., fire, flooding)?

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

4. Individual species sensitivities
How sensitive are key species in the administrative unit to climate change (e.g., flagship species, ecosystem engineers, keystone species)

Not very sensitive		Moderately sensitive		Very sensitive
1	2	3	4	5

5. Sensitive habitats
Does the administrative unit contain (or is it characterized by) many habitats that will be particularly sensitive to climate change (e.g., vernal pools, shallow wetlands, alpine areas, coastal marshes, coral reefs)?

Not many				Many
1	2	3	4	5

6. Non-climatic stressors
To what degree are the habitats in the administrative unit negatively impacted by other, non-climatic stressors (e.g., invasive species, overharvest, habitat loss)?

Slightly impacted				Severely impacted
1	2	3	4	5

Foothill Yellow-legged Frog – Summary information

Natural History (NatureServe 2011)

- This species inhabits partially shaded, rocky streams at low to moderate elevations in areas of chaparral, open woodland, and forest. It seeks cover at the bottom of a pool when startled. Habitats, in order of decreasing favorability, include: (1) partially shaded, small perennial streams, at elevations of 30-1,000 meters, with at least some cobble-sized rocks; riffle areas and stream depth rarely greater than 1 meter, (2) intermittent, small, partly shaded, rocky streams displaying seasonal riffle habitat, (3) large (consistently greater than 1 meter in stream depth), partly shaded, perennial streams with rocky or bedrock habitat, (4) open perennial streams with little or no rocky habitat.
- Adults are mainly invertivorous; larvae eat algae, organic debris, plant tissue, and minute organisms in water.
- These frogs are inactive in cold temperatures and reduce activity during hot, dry weather. Usually they are most active during daylight hours.
- Breeding occurs between mid-March and early June, after stream flow subsides from winter storms and runoff.
- Eggs often are laid in clusters of about 1,000 eggs/mass. Larvae hatch in about 5 days at 20 ^{o}C, and metamorphose in summer.
- Species resident (it does not migrate) in areas where it is found.
- Barriers to movement include: busy major highway, especially at night, such that frogs rarely if ever cross successfully; urban development dominated by buildings and pavement; habitat in which site-specific data indicate the frogs virtually never occur.
- Available information indicates that individual ranids occasionally move distances of several kilometers (*R. luteiventris*, *R. blairi*) but most individuals stay within a few kilometers of their breeding sites (*R. aurora draytonii*, *R. capito*, *R. clamitans*, *R. luteiventris*). Similarly, maximum distance between capture points generally is a few kilometers or less (*R. aurora*, *R. catesbeiana*, *R. luteiventris*, *R. muscosa*). Dispersal data for juveniles are lacking for most species.

Disturbances (NatureServe 2011)

- Occurs in California and western Oregon; substantial ongoing decline, apparently due to habitat alteration, impacts of airborne agrochemicals, and/or effects of exotic species, UV-B radiation, and because recolonization abilities may be greatly restricted by local extirpation patterns.
- Stream scouring (may negatively impact frogs in streambed hibernation sites), stabilization of historically fluctuating stream flows as a result of dam construction, introduced incompatible aquatic animals, riverine and riparian impacts of non-selective logging practices, and other habitat degradation and disturbance caused by livestock grazing and in-stream mining all negatively impact the species.
- Adults, larvae, and/or eggs are vulnerable to an array of non-native predators such as predatory fishes (Paoletti et al. 2011), bullfrogs (*Rana catesbeiana*), and crayfish.
- Dam-controlled flows and lack of winter flooding may result in stable pool areas with established aquatic vegetation, and this may increase suitable habitat for exotic species such as bullfrogs. Decreased flows may force frogs into permanent pools where they are more susceptible to predation.

- River water velocity disturbance (for recreational flows for white water boating or peaking releases for hydroelectric power generation) have been shown to affect tadpole development and survivorship (Kupferberg et al. 2011)
- Interspecific matings between male *R. boylii* and female bullfrogs have been observed; these interactions with non-native bullfrogs might reduce the reproductive output of *R. boylii*.
- Logging and erosion from road cuts have resulted in periodically high levels of stream siltation in some areas of northern California. High levels of silt may inhibit the attachment of the egg mass to the substrate. Excessive accumulation of silt on the egg masses may have adverse effects on embryo development. Silt also reduces the interstitial spaces available for use by tadpoles, reduces algal growth on which the tadpoles feed, and can have a significant negative impact on adult frog food resources (e.g., aquatic macro-invertebrates).
- As for many other amphibians, its numbers have declined due to exposure to wind-borne pesticides (Davidson et al. 2002; Davidson 2004; Sparling & Fellers 2009).

Known climate change responses

- Periods of unusually warm summer water temperatures in northern California may be linked to outbreaks of the parasitic copepod (*Lernaea cyprinacea*) and malformations in tadpoles and young of the year (Kupferberg et al. 2009).
- Although it was not formally assessed by (Lawler et al. 2010), it is expected to shift its range as other Rana species.
- The species seemed to decline in a stronger fashion as sites got drier in CA (Davidson et al. 2002)

Comments on the species conservation status and threats

The species formerly was regarded as at least locally abundant in southwestern Oregon, but now it is rare or absent through the entire western half of the Oregon range. This frog has disappeared from more than 50% of historical locations in Oregon and is presumed extirpated from most of the northern and far eastern portions of the range in Oregon (NatureServe 2011).

Umpqua National Forest / Klamath Basin Wildlife Refuge - Summary Information

Basics

The Umpqua National Forest (UNF) is nestled on the west side of the Cascade Mountains. Explosive geologic events have shaped the distinctive landscape on the 984,602-acre forest, and provide spectacular scenery as well as an abundance of natural and cultural resources. Visitors discover a diverse place of thundering waters, high mountain lakes, heart-stopping rapids, and peaceful ponds. The Forest is characterized by its many waterfalls, including the 272-foot Watson Falls on the North Umpqua Highway. The Boulder Creek Wilderness, 19,100 acres, is entirely within the Forest boundaries. Two other wilderness areas are shared with other Forests: Rogue-Umpqua Divide Wilderness, 26,350 acres, and Mt. Thielsen Wilderness, 26,593 acres.

As other National Forests, the Umpqua National Forest mission includes promoting ecosystem health (including protection of species and natural systems), providing multiple benefits to people (including diverse commercial and non-commercial human uses), developing the best scientific information available to deliver technical and community assistance and delivering effective public service. Activities in line with this mission include timber management, conservation and restoration, watershed management, fire management, recreation and archaeology among others.

The Klamath Basin National Wildlife Refuge Complex is operated by the United States Fish and Wildlife Service located in the Klamath Basin of southern Oregon and northern California near Klamath Falls, Oregon. It consists of Bear Valley, Klamath Marsh and Upper Klamath National Wildlife Refuge (NWR) in southern Oregon and Lower Klamath, Tule Lake, and Clear Lake NWR in northern California.

The Lower Klamath NWR was the first waterfowl refuge in the United States. Consisting of 46,900 acres, it includes shallow freshwater marshes, open water, grassy uplands, and croplands that are intensively managed to provide feeding, resting, nesting, and brood rearing habitat for waterfowl and other water birds. Clear Lake NWR has an area of 46,460 acres. About 20,000 acres is open water. The balance is the surrounding upland habitat of bunchgrass, low sagebrush, and juniper. Upper Klamath NWR is composed of 15,000 acres of mostly freshwater marsh and open water. Tule Lake NWR encompasses 39,116 acres of mostly open water and croplands. Klamath Marsh NWR consists of 40,646 acres of freshwater marsh and adjacent meadows. Bear Valley NWR protects a vital night roost site for wintering bald eagles. It consists of 4,200 acres of largely old growth Ponderosa Pine, Incense-cedar, White Fir and Douglas-fir forest.

Klamath Basin Refuges consist of a variety of habitats including freshwater marshes, open water, grassy meadows, coniferous forests, sagebrush and juniper grasslands, agricultural lands, and rocky cliffs and slopes. These habitats support diverse and abundant populations of resident and migratory wildlife with 433 species having been observed on or near the Refuges. In addition, each year the Refuges serve as a migratory stopover for about three-quarters of the Pacific Flyway waterfowl, with peak fall concentrations of over 1 million birds. Approximately 17,000 acres in Tule Lake NWR are leased by potato, onion, horse radish, alfalfa, and cereal grains within the Public Lease Lands program administered by the U.S Bureau of Reclamation. Other activities conducted in the NWR complex include hunting, recreation, wildlife observation, water production, wildlife conservation, among many others.

Species

The Umpqua National Forest is at the juncture of several distinct geologic provinces, providing a wide spectrum of habitat for a diversity of plants and wildlife. The Forest is home to 18 fish species, including winter steelhead (*Oncorhynchus mykiss*), Chinook (*Oncorhynchus tschawytscha*) and coho (*Oncorhynchus tschawytscha*) salmon, and sea-run cutthroat trout (*Oncorhynchus tschawytscha*). The Forest abounds with 66 mammal species, including bobcat, American marten (, Pacific fisher (*Martes pennati*), Pacific fringed myotis (*Myotis thysanodes vespertinus*); 236 bird species, including Northern Spotted Owl (*Strix occidentalis caurina*), Yellow Rail (*Coturnicops noveboracensis*); and 27 reptile and amphibian species, including Northwestern pond turtle (*Clemmys marmorata marmorata*) and Southern torrent salamander (*Rhyacotriton variegatus*). Anadromous, or sea-going fish enjoy 359 miles of streams with thousands more miles of streams covering the forest landscape.

Among the species found on the Klamath Basin NWR complex are: White-faced Ibis (*Plegadis chihi*); Great Blue Heron (*Ardea herodias*); Black-crowned Night Heron (*Nycticorax nycticorax*), Great (*Ardea alba*) and Snowy (*Egretta thula*) egrets; Double-crested Cormorant (*Phalacrocorax auritus*); Bald Eagle (*Haliaeetus leucocephalus*); Greater Sage Grouse (*Centrocercus urophasianus*); Western (*Aechmophorus occidentalis*), Clark's (*Aechmophorus clarkii*) and Eared (*Podiceps nigricollis*) grebes; American white pelican (*Pelecanus erythrorhynchos*); Greater White-fronted (*Anser albifrons*), Snow (*Chen caerulescens*), Ross's (*Chen rossii*), Cackling (*Branta hutchinsii*) and Canada geese (*Branta canadensis*), all of which nest in the Arctic tundra; and several species of terns (*Sterna spp.*) and gulls (*Larus spp.*). Other species that can be found on this complex include: Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers, both listed as Endangered; pronghorn antelope (*Antilocapra americana)*, mule deer (*Odocoileus hemionus)*, and Wolverine (*Gulo gulo*).

Key issues

Disturbances: Fire suppression practices have significantly increased the amount of fire fuel in the UNF forests. Currently, the Forest Service is evaluating a thinning and clean-up project to reduce the probability of large wildfires.

Invasive species: Feral swine (*Sus sp.*) are invasive in OR. They are free-roaming pigs found on public or private land. They vary in size and coloration. They damage habitat (restricting timber growth, reducing and/or removing understory and compacting soils) and forage on a number of items (such as acorns, forbs, grasses, fungus, leaves, berries, fruits, roots, tubers, corn and other agricultural crops, insects, crayfish, frogs, salamanders, snakes, mice, eggs of groundnesting birds, small mammals, fawns, lambs, calves, kid goats and carrion) and they can transmit disease to wildlife, livestock and humans.

Nutria (*Myocastor coypus*) causes stream bank erosion and subsequent sedimentation of streams with their burrowing and feeding. They are such voracious feeders that they can denude areas of vegetation, which are referred to as “eat outs.” The burrowing activity of nutria is known to cause damage to road beds, levees, dikes, and other structures

Invasive aquatic species are a serious problem in Oregon. They wreak havoc on lakes, rivers, streams and wetlands. There are currently over 134 nonindigenous aquatic species reported in Oregon. They include bullfrogs (*Rana catesbeiana*), crayfish, invasive fish and more. For example, most algae blooms are harmless, but some blue-green algal blooms can produce toxins that may sicken people and animals. Blue-green algae are found in many nutrient-rich Oregon lakes.

Disease and pests: UNF has been affected by Mounatin Pine Beetle (*Dendroctonus ponderosae*) outbrakes killing large numbers of Lodgepole pines (*Pinus contorta*) and other tree species, especially near Diamond Lake.

Water supply conflicts: Like most places in the West, the Klamath Basin is naturally arid and rainfall is very limited. There is conflict over the allocation of water supply to make natural and human uses compatible.

Climate change: Climate change has contributed to an increase in the extent and severity of Mountain Pine beetle outbreaks. Insect outbreaks such as this represent an important mechanism by which climate change may undermine the ability of northern forests to take up and store atmospheric carbon and to recover from disturbances (Kurz et al. 2008).

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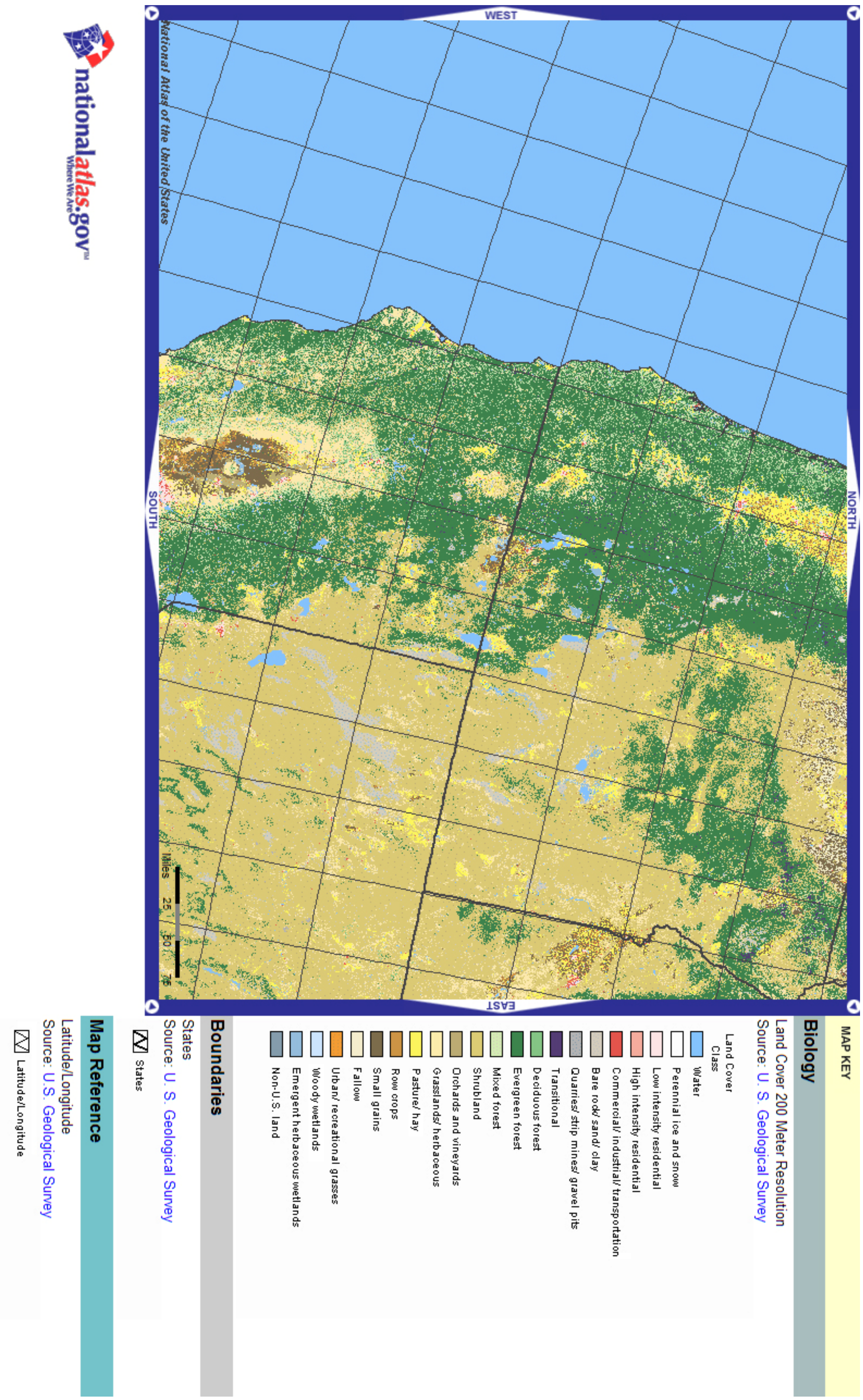
Umpqua National Forest / Klamath Basin Wildlife Refuge land cover



Exercise 2.2: Assessing exposure

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

Output: A discussion of exposure for your species and your administrative unit The goal of the questions below is to get you thinking about what elements of exposure are most important for assessing the vulnerability of the particular species, habitats, or places with which you are concerned. The metrics of change most commonly presented in the media—e.g. changes in average global or regional temperature and changes in average global or regional rainfall—aren't always the most appropriate metrics for a particular VA.

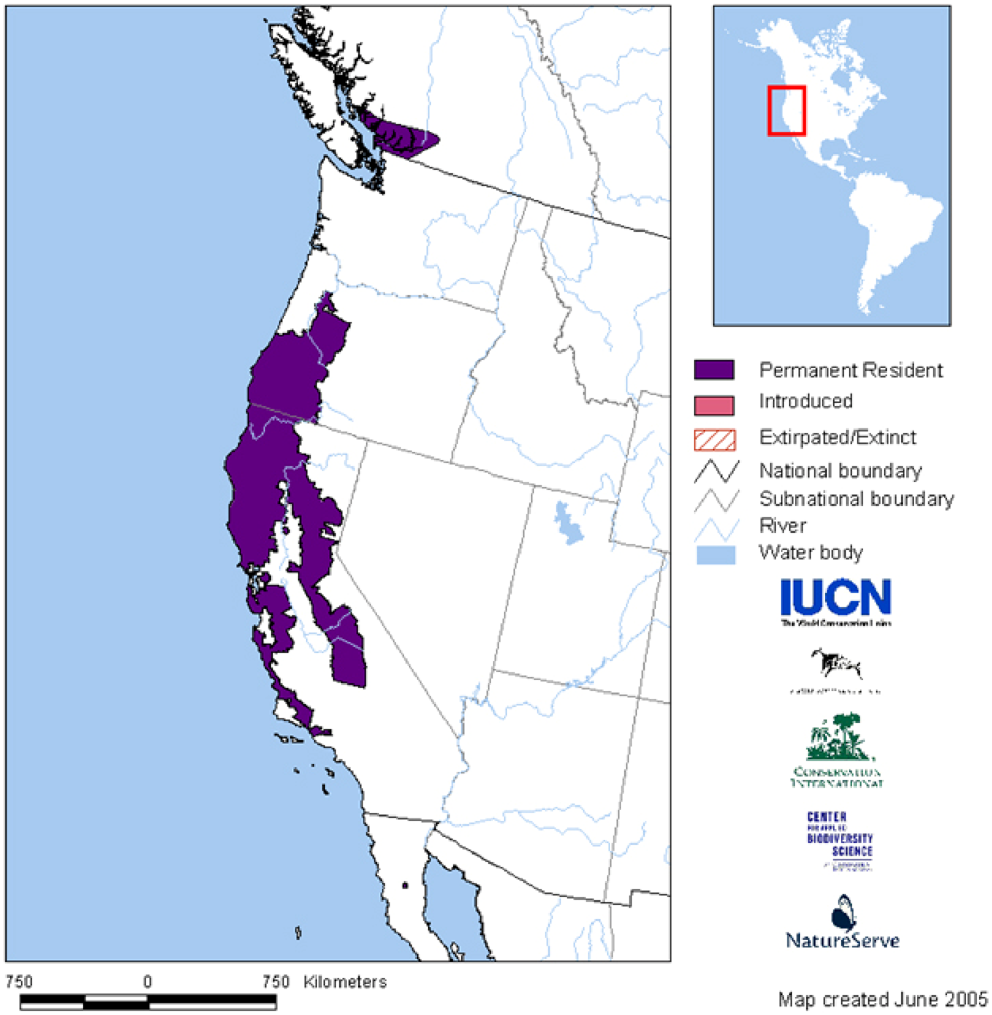
Resources:

I. Range (for species) or boundaries (for habitat/administrative unit)
II. Shaded relief map for relevant area (created using the National Atlas; can go to nationalatlas.gov and look in the geology layer if you want to zoom in)
III. Maps of projected changes in various climate variables for the relevant area.

Questions to consider:

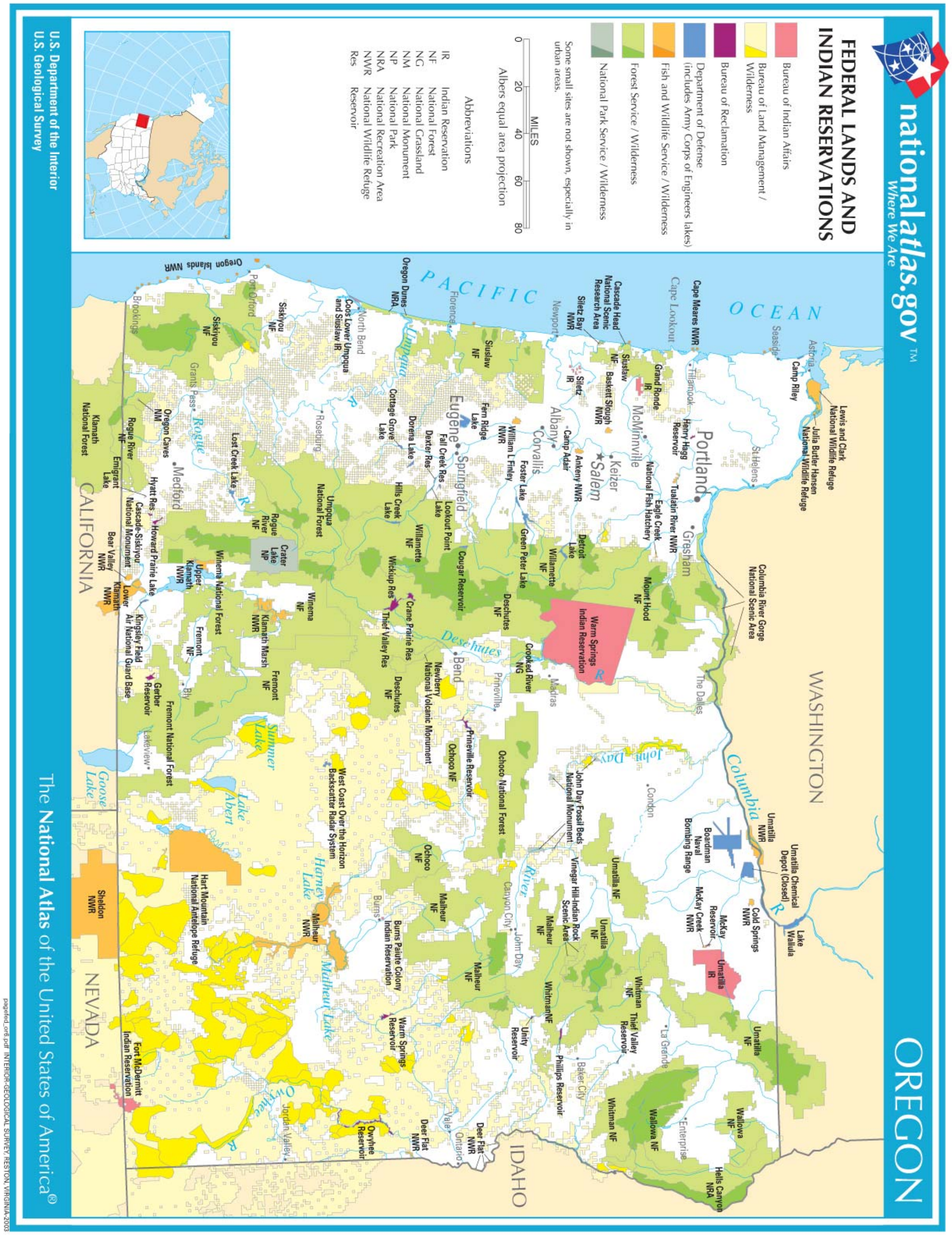
1. What elements of exposure are likely to be most relevant or important for the species in question? For the habitat or administrative unit? (NOTE: there may be elements that are in the "most relevant" category that have not been provided to you in the packet. List any layers missing that you think would help you better evaluate exposure).
2. For species: What factors are most important in determining the species' range? Think not just about climate variables, but about other factors as well (e.g. presence of particular plants, absence of particular competitors, etc.). How might this influence the variables on which you chose to focus?
3. For administrative units: What are the goals, vision, or mandate for this administrative unit? What factors are most important in determining the ability of the unit to meet these goals, vision, and mandates?
4. What factors might influence exposure? That is, what factors influence the actual amount of climatic change experienced by the species or place in question? For example, some types of air pollution reflect heat and thereby slow warming; type and density of plant cover can influence heating, cooling, moisture, and fire regime.
5. How would you express exposure for the species in question—maps of each variable separately? Of only the most important variables? A combined map showing average change in all variables? A single ranking or score for exposure across the entire range/unit? Exposure maps or scores for a few key species or habitat types within the administrative unit? Think about various ways you might want to use the VA results and how different ways of expressing exposure (and ultimately overall vulnerability) might be better or worse for each type of use.

Foothill Yellow-legged Frog Range Map



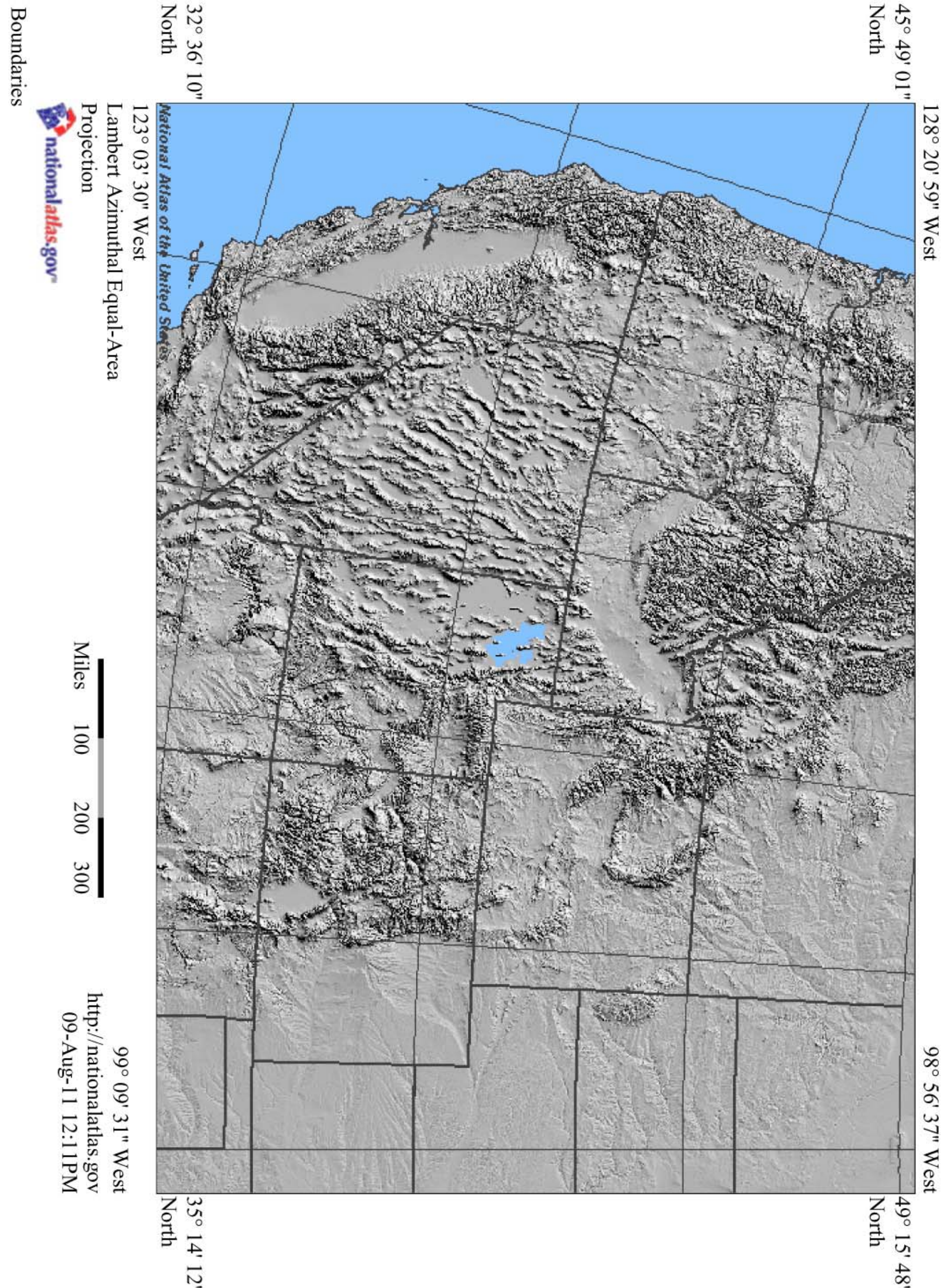
Range includes Pacific drainages from the upper reaches of the Willamette River system, Oregon (west of the Cascades crest), south to the upper San Gabriel River, Los Angeles County, California, including the coast ranges and Sierra Nevada foothills in the United States (Stebbins 2003). The species occurred at least formerly in a disjunct location in northern Baja California. Two specimens were collected in 1965 at an elevation of 2,040 meters at the lower end of La Grulla Meadow, Sierra San Pedro Martir, Baja California, Mexico; subsequent searches have not detected the species in that area. The species apparently has disappeared from portions of its historical range, especially in southern California. Extant *R. boylii* populations are not evenly distributed in California; in the Pacific northwest, 40 percent of the streams support populations, whereas that number drops to 30 percent in the Cascade Mountains (north of the Sierra Nevada), 30 percent in the south coast range (south of San Francisco), and 12 percent in the Sierra Nevada foothills. Elevational range extends from sea level to around 2,130 meters (NatureServe 2011).

Umpqua National Forest / Klamath Basin Wildlife Refuge boundary

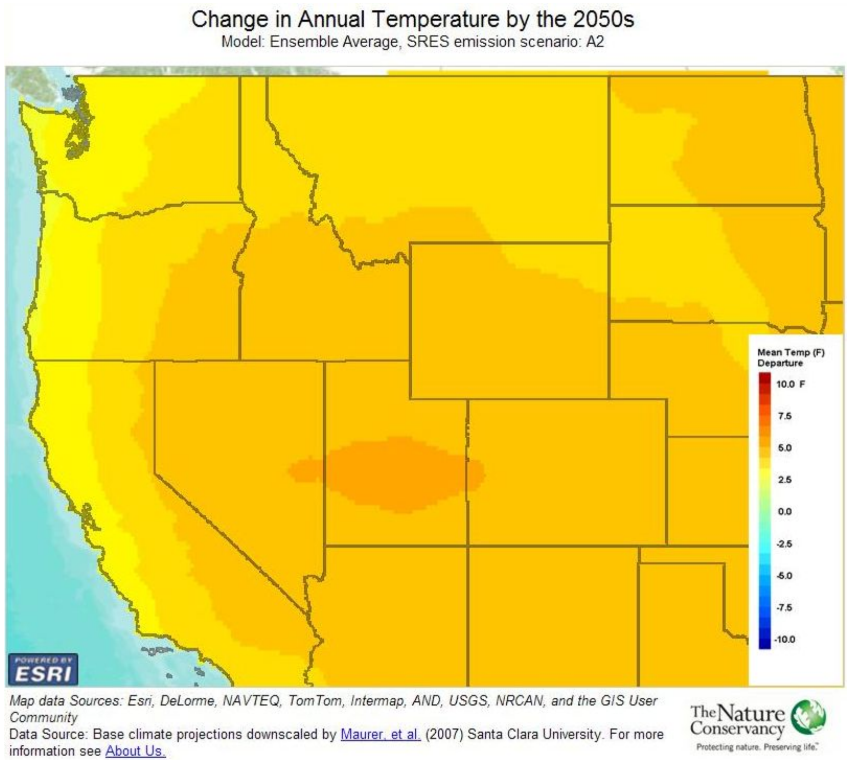


Foothill Yellow-legged Frog exposure assessment tools

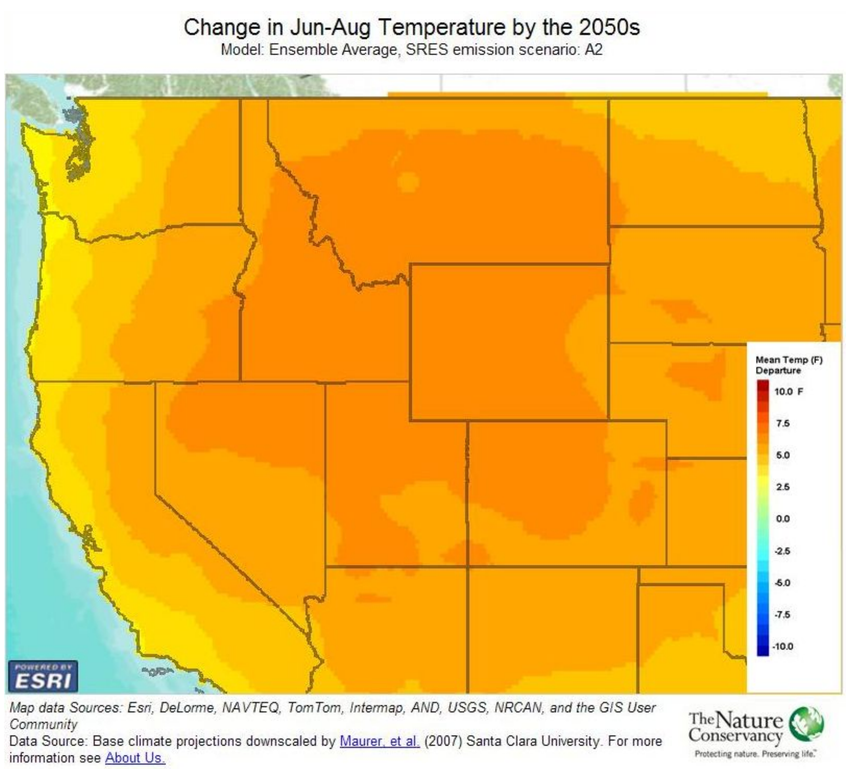
Topography



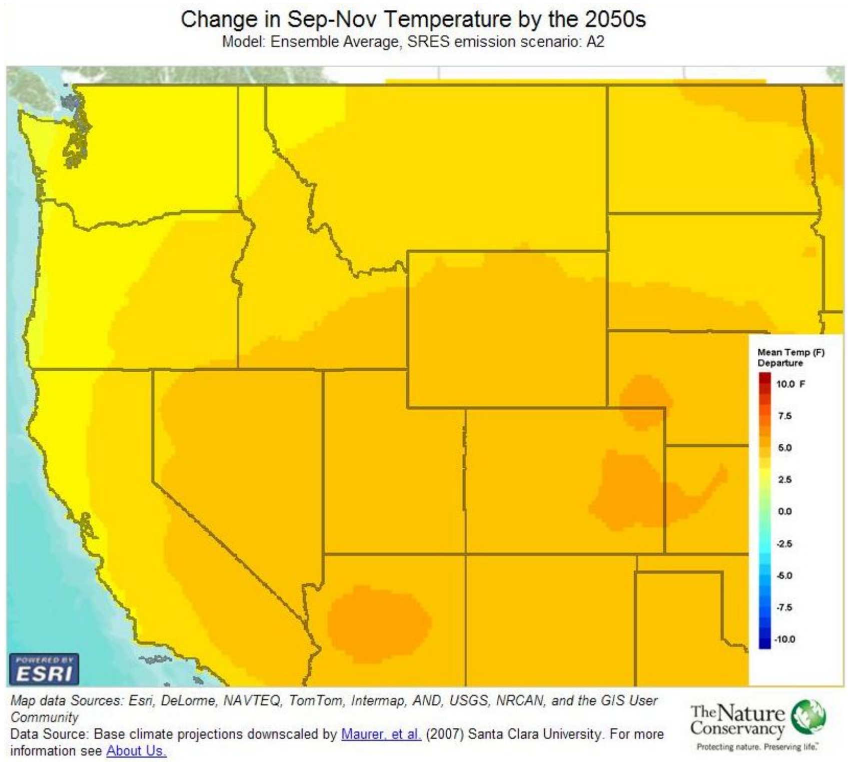
Annual temperatures



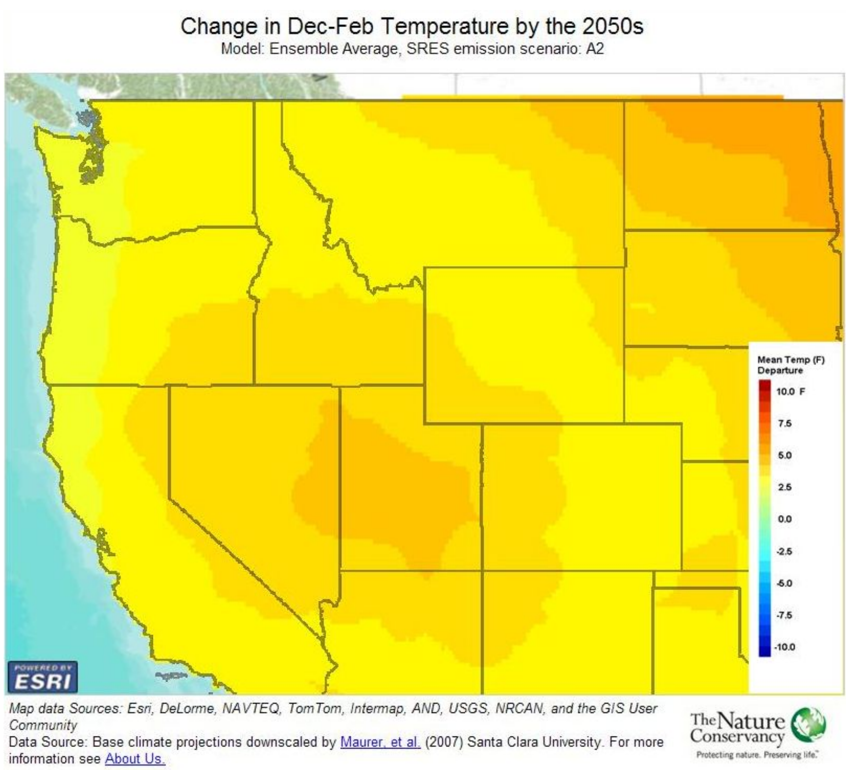
Summer temperatures



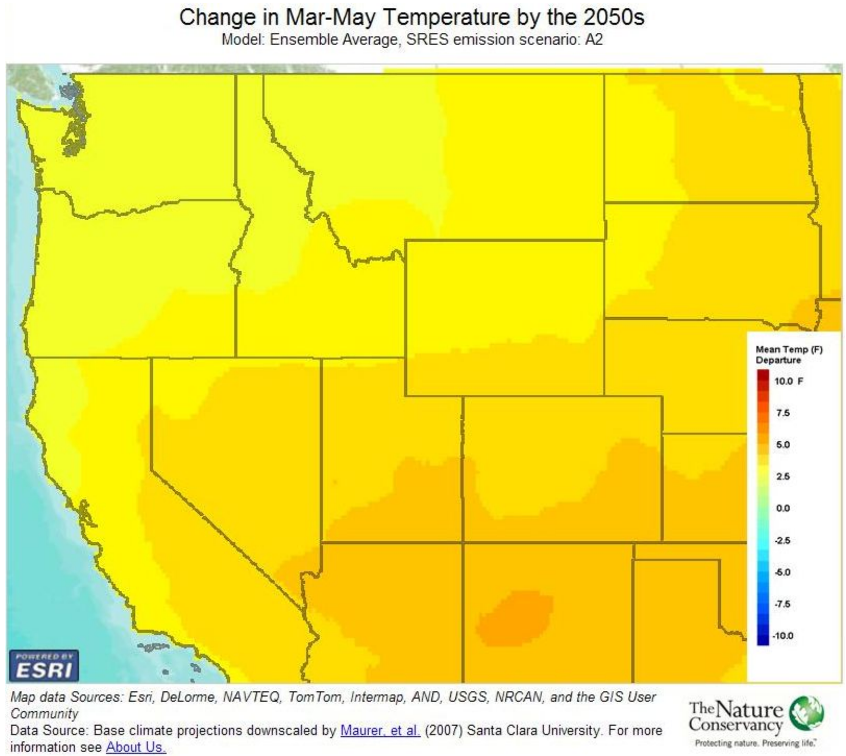
Fall temperatures



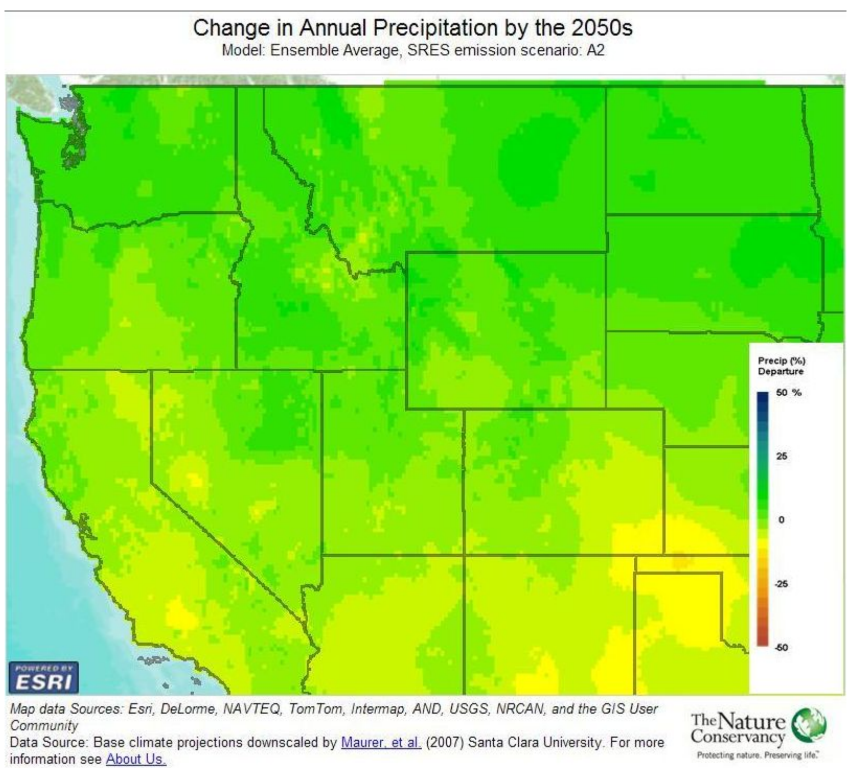
Winter temperatures



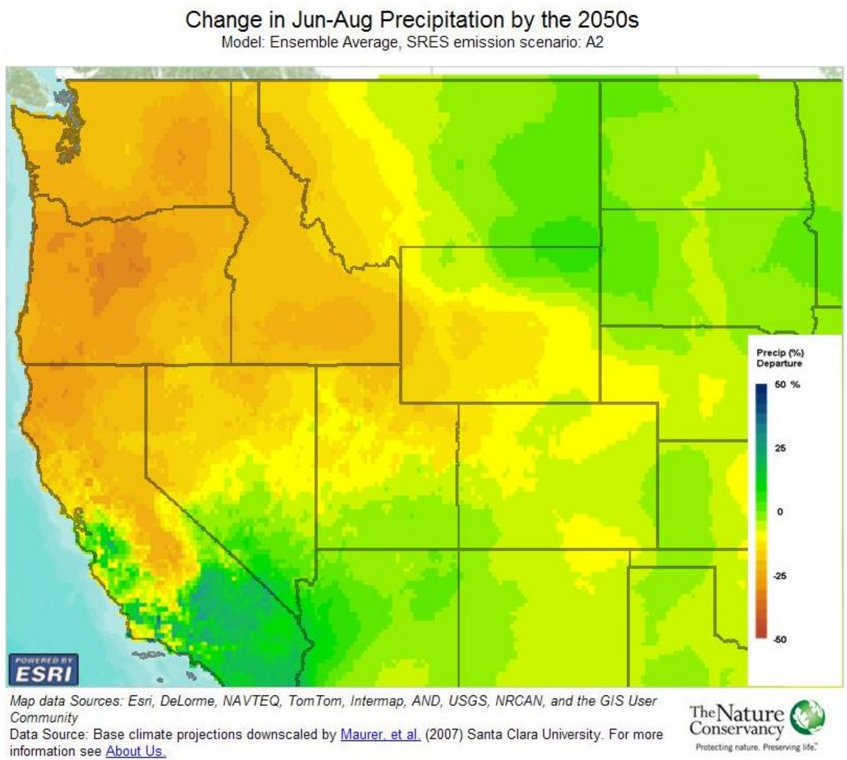
Spring temperatures



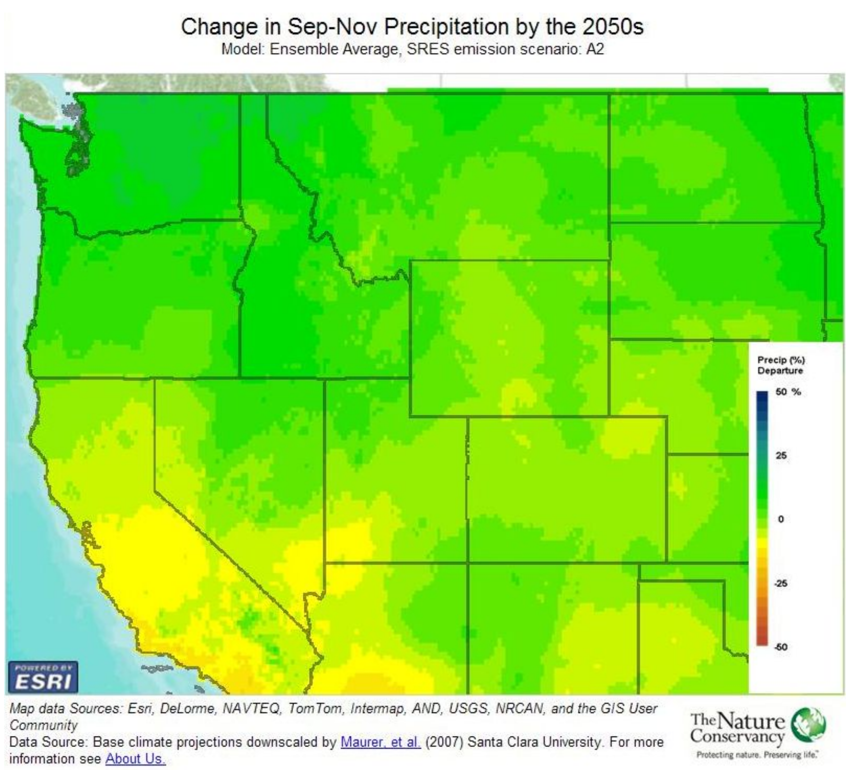
Annual precipitation



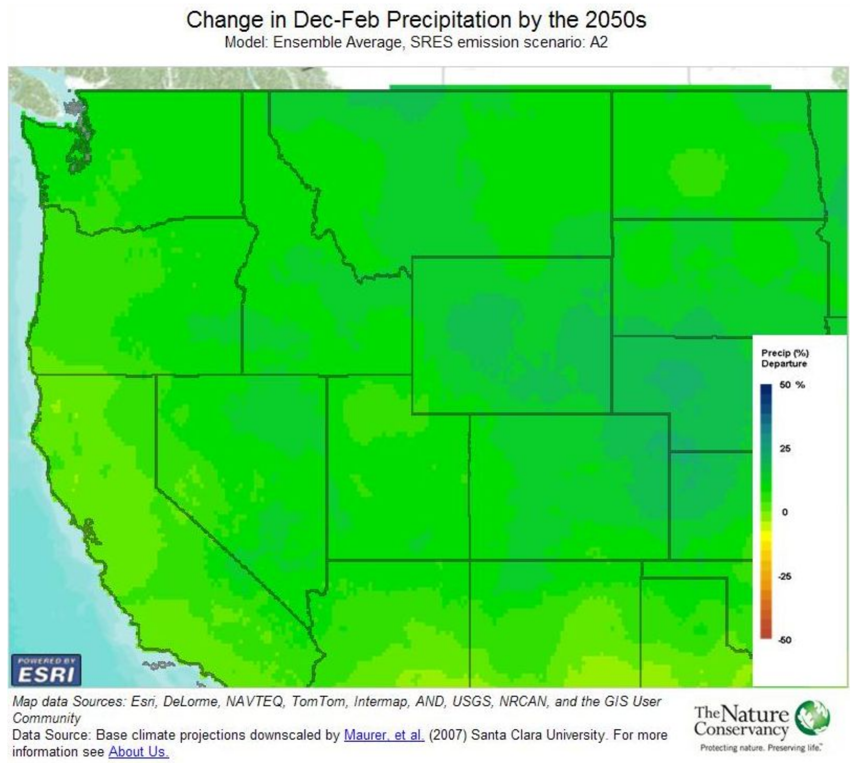
Summer precipitation



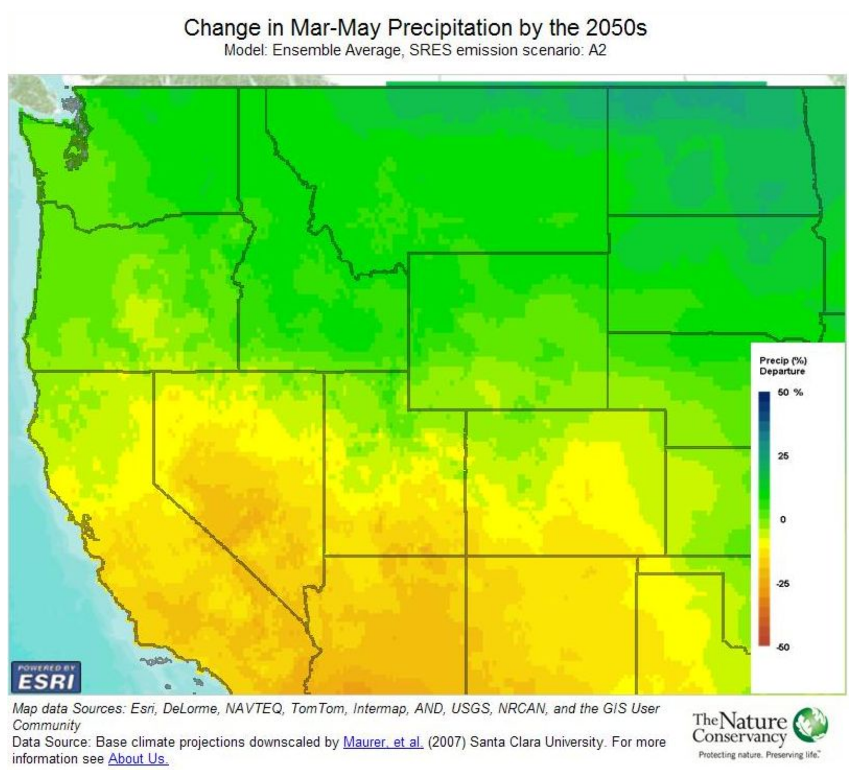
Fall precipitation

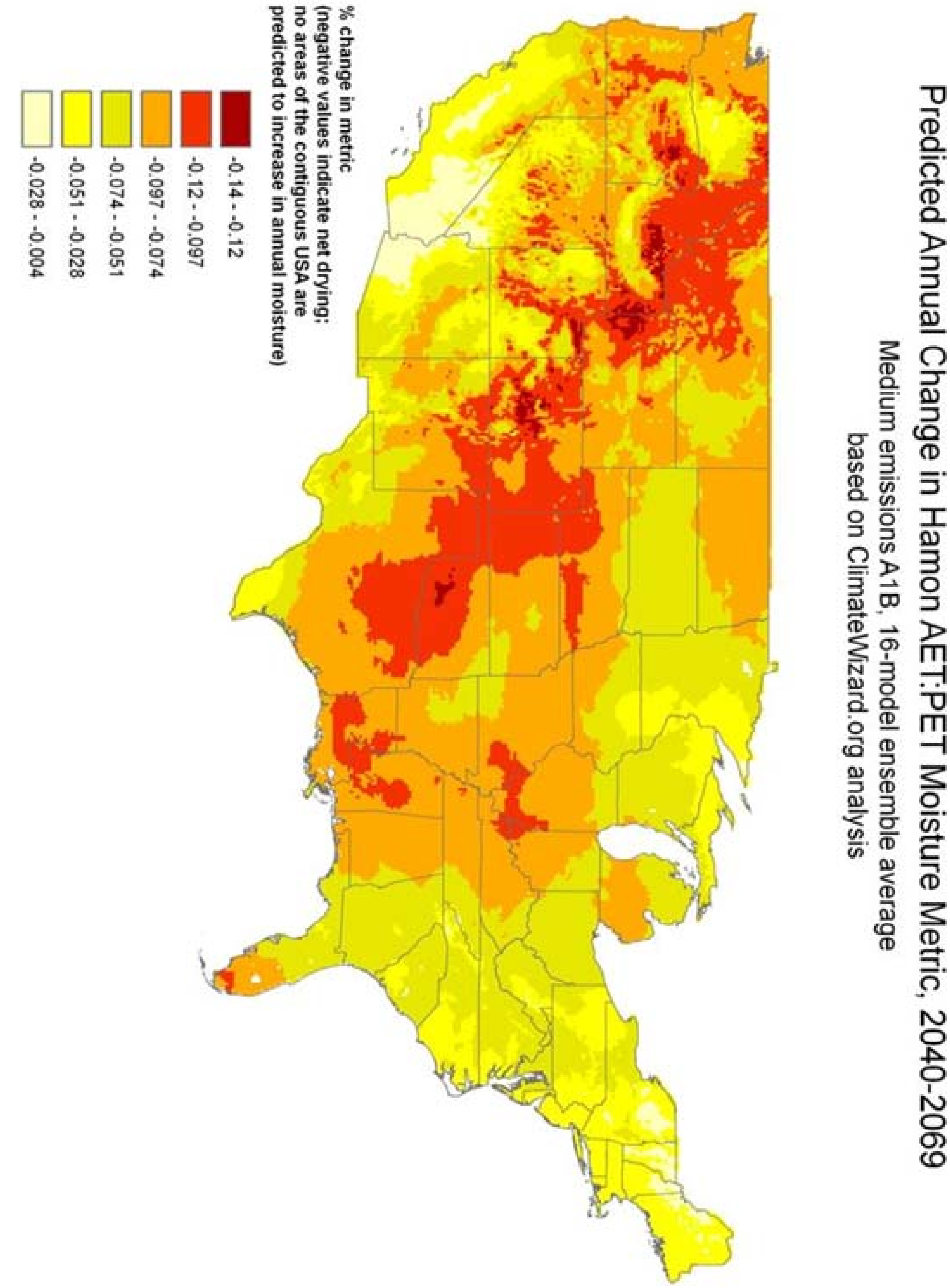


Winter precipitation



Spring precipitation




Predicted Annual Change in Hamon AET:PET Moisture Metric, 2040-2069
Medium emissions A1B, 16-model ensemble average
based on ClimateWizard.org analysis
% change in metric
(negative values indicate net drying;
no areas of the contiguous USA are
predicted to increase in annual moisture)
-0.14 - -0.12
-0.12 - -0.097
-0.097 - -0.074
-0.074 - -0.051
-0.051 - -0.028
-0.028 - -0.004

Exercise 2.3: Adaptive Capacity and Assessing Vulnerability

Length: 60 minutes
Lead-- All instructors needed to help groups
Format: small group

In this exercise, we're asking you to think about the ability of species and habitat/administrative units to respond to climate change in ways that minimize its negative effects. Remember, don't get too caught up in whether you'd categorize a particular characteristic as adaptive capacity vs. exposure or sensitivity; the key is to think about vulnerability from a number of angles.

Output:

1. A measure of adaptive capacity for your species and your administrative unit
2. An overall vulnerability score/ranking for your species and administrative unit. Do this by pooling the results of your sensitivity, exposure, and adaptive capacity analyses in a way that makes sense to you. This could be qualitative or quantitative, spatial or numeric, it's up to you. Just be ready to defend your choices!

Resources:

I. Species/place information from the Sensitivity Exercise
II. Highways map
III. Pollution sources map (Air Releases, Superfund National Priorities List Sites, Toxics Release Inventory, Water Discharge Permits; (created using the National Atlas; can go to nationalatlas.gov and look at the "environment" layer if you want to zoom in)
IV. GAP protected areas map

Questions to consider:

Species:

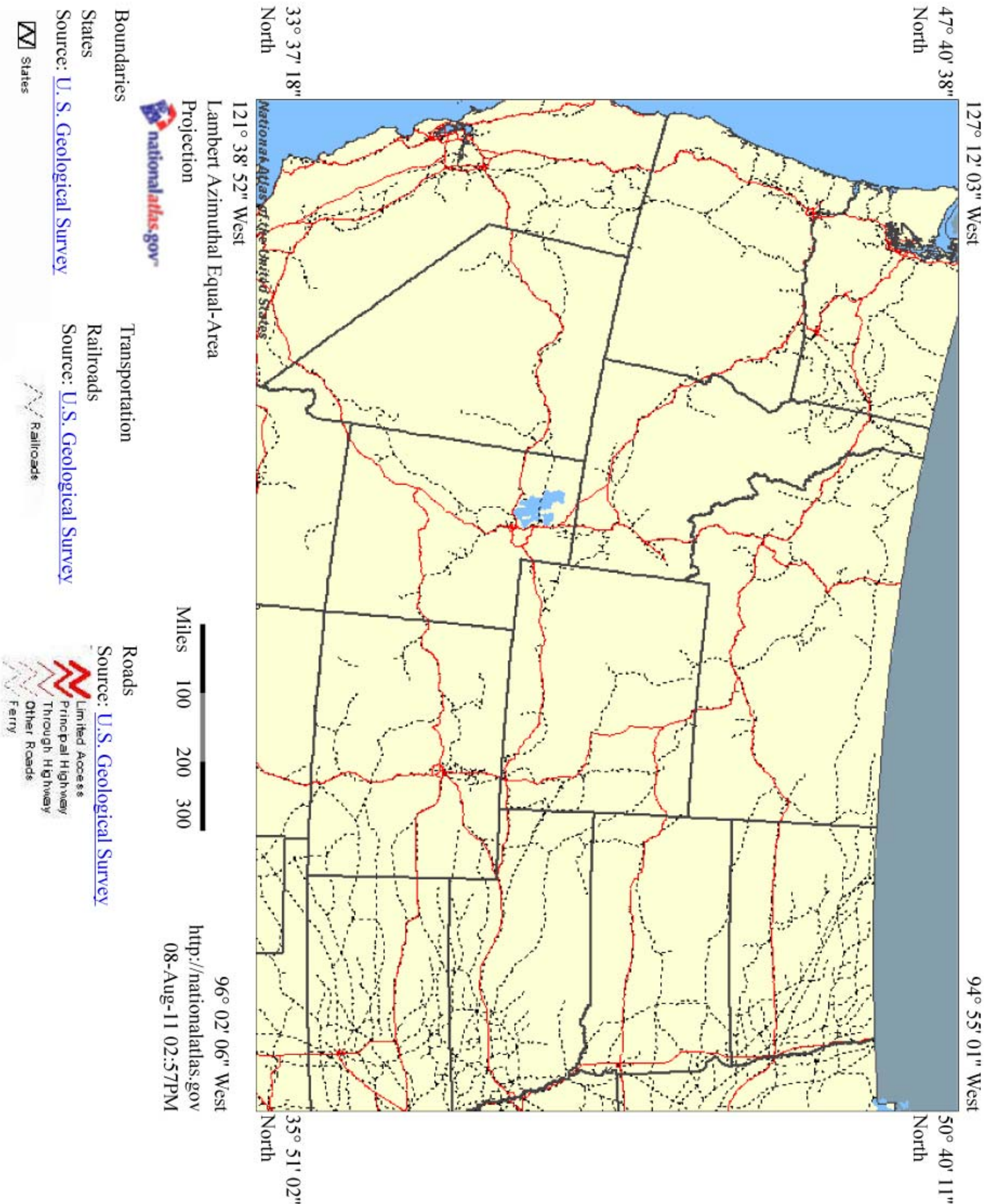
- Is its evolutionary rate fast? Slow? Somewhere in between?
- Roughly speaking, is there sufficient genetic diversity or availability of favorable alleles within the species to support evolutionary adaptation?
- Are individuals in this species capable of phenotypic adjustment in response to changes in their environment?
- Is there evidence that this species is already adjusting/adapting to change (e.g. shifting behavior, range, host plants, etc.)?
- Is the geography, land use, etc. such that it would be possible for individuals to seek out refugia during times of particular climate stress (e.g. prolonged heat wave)?
- Is the geography, land use, etc. such that it would be possible for species range shift to occur? Remember that species' range shifts typically happen by differential survival and reproduction, not by the purposeful movement of individuals to new locations.
- Are there multiple populations with enough connectivity among them to allow for rescue effects and gene flow?

Administrative unit/habitat:

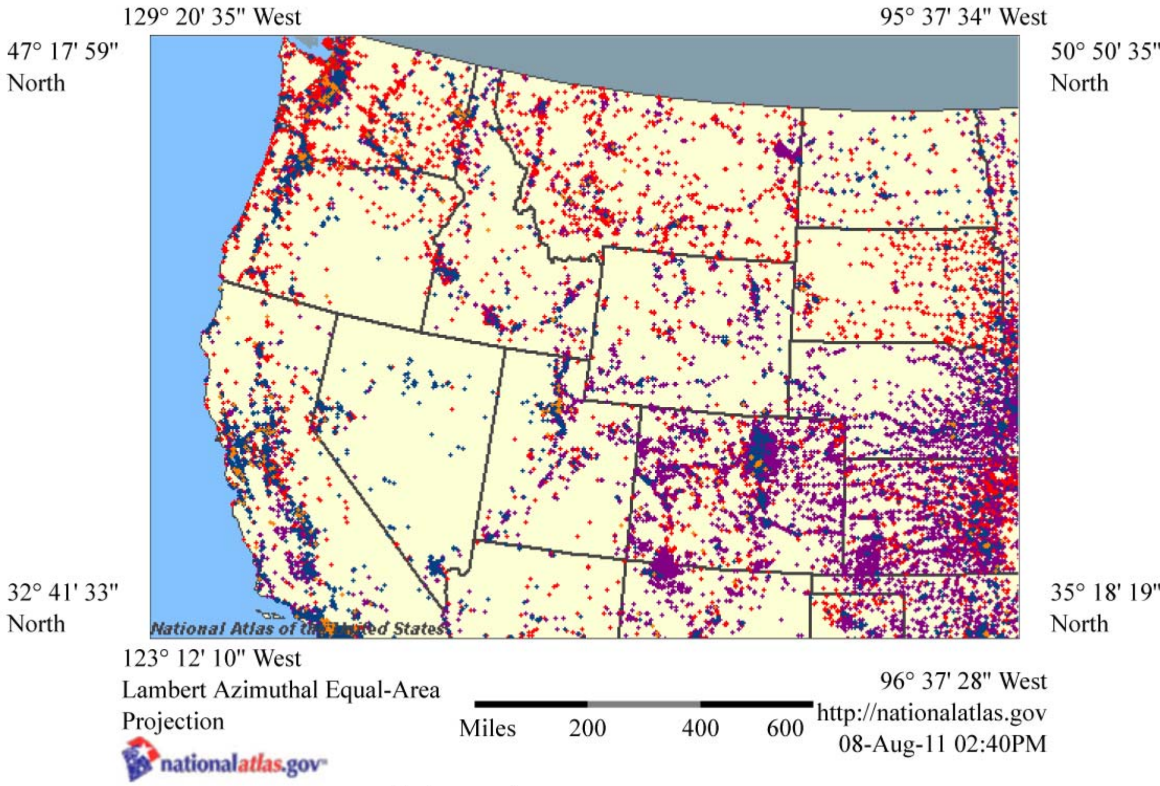
- What are the defining characteristics of the habitat community, and how vulnerable are they to climate change? E.g. presence of particular minerals in the soil may not be affected by climate change, whereas presence of vernal pools may be heavily affected.
- Is there a diversity of species in each functional group within the community/habitat?
- Is the geography, land use, etc. such that it would be possible for the community/habitat to shift location over time?
- Are there microclimates within the area that could support refugial communities?
- What is the nature of people's relationship to this habitat/community? Does it occur in areas where there is strong development pressure? Do people value this habitat because of services it provides (e.g. clean water, hunting or fishing opportunities, etc.)?
- Consider adaptive capacity of species and habitats within the unit.
- How rigid/specific are the rules governing management of the unit (e.g. for National Parks, what is in the enabling legislation)?
- Is there a General Management Plan or something similar? If so, how does this affect the adaptive capacity of the unit?

Foothill Yellow-legged Frog Adaptive Capacity Assessment Tools

Roads



Environmental Risk Sites



Boundaries

States
Source: U. S. Geological Survey

States

Environment

Water Discharge Permits
Source: U.S. Environmental Protection Agency

Water Discharge Permits

Air Releases
Source: U.S. Environmental Protection Agency

Air Releases

Toxics Release Inventory
Source: U.S. Environmental Protection Agency

Toxics Release Inventory

Superfund National Priorities List Sites
Source: U.S. Environmental Protection Agency

Superfund National Priorities List Sites

Protected Areas in Foothill Yellow-legged Frog range